

Metallurgical & Chemical Engineering

Volume XIII, Number 11

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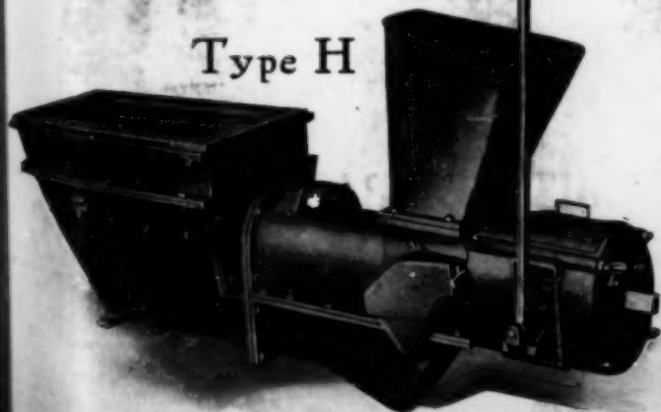
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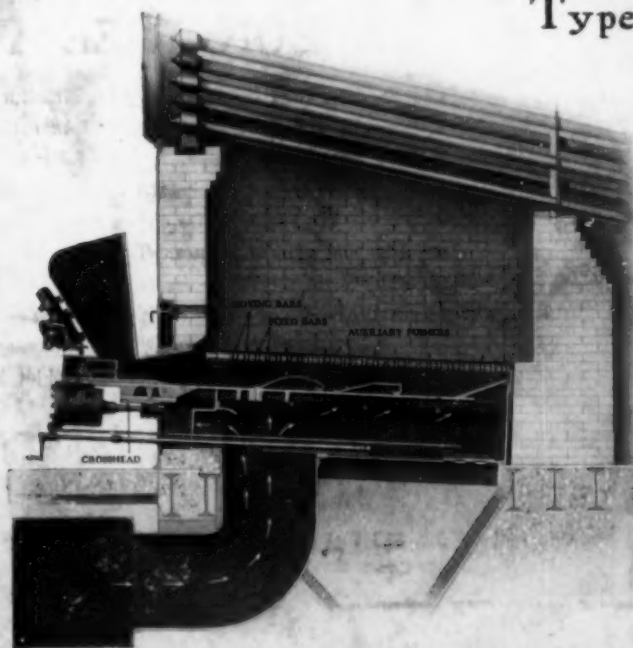
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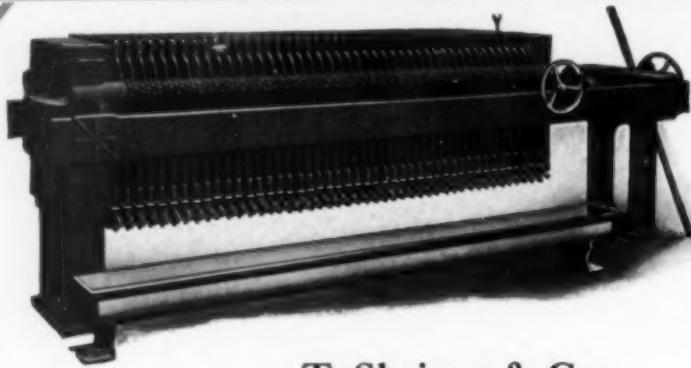
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What the Chemical Industry Has a Right to Expect from the American Nation

"The only true basis on which the *independence* of our country can rest, are agriculture and manufacture. To the promotion of these nothing tends to a higher degree than *chemistry*." These words were placed as a motto above the exhibit in the American Electrochemical Society booth in the First National Exposition of Chemical Industries in New York City last week. They were taken from Thomas P. Smith's oration before the Chemical Society of Philadelphia on April 11, 1789. They are as fresh and true to-day as they were 117 years ago. But the American nation as a whole is only now beginning to grasp the idea of the intimate relationship between its very independence and chemistry.

The European war brought about suddenly this recognition. The general public then realized for the first time how interwoven the work of the chemist is with the whole industrial life of the country, and because the existing chemical industries could not supply all the country's needs, those who were left in want (because they had never shown any particular appreciation of American chemical industries) combined with American newspapers in an abuse of the American chemist that was as unfair as it was stupid. But the American chemist quietly went his way and did things, many things. Part of this activity will stop when the war stops, as it has to do with war materials. But by far the most of the present activity in the chemical industries will be lasting for the benefit of the whole country, if the American nation is willing that it be so. What is it that the chemical industry has a right to expect from the American nation? Nothing more nor less than a fair attitude of mind of the American nation toward American chemistry: a fair appreciation of its accomplishments and aims, a fair recognition of the fact that chemical brains need capital for realization of their ideas and that capital needs fair protection, not forever, but for a sufficient time to permit the chemical manufacturers to adjust themselves to the changed conditions and new requirements. Whatever was said in the meetings held in connection with the Chemical Exposition by Dr. Baekeland, Mr. Gross, Dr. Herty, Mr. Stone, and others on needed reforms, may be summed up in the single demand for plain fairness. And this augurs well. For the American people may be misled for a while, but ultimately they will always be found fair and right.

A Scarcity of Steel

It is being said in the steel trade that there is a scarcity of steel. It requires some knowledge of steel trade parlance to appreciate the significance of the

statement. The meaning is not that the supply has been curtailed so as to result in a scarcity, nor is it yet that the demand for steel products has outrun the supply. The precise meaning the trade attaches to the expression is that the steel ingot making capacity has been found to be far short of the supply of raw materials for steel making on the one hand, and far short of the rolling and other steel finishing capacity on the other hand.

The steel industry as a whole is busy, but the steel-making departments are the busiest. The steel interests still have a few idle blast furnaces that could be blown in, and there are many merchant furnaces idle. There is an abundance of ore, and coke is so plentiful that Connellsville furnace coke for spot shipment has been selling at one-half the price it commanded the last time the market price of steel billets mounted to the present level. The majority of the steel-finishing departments are not fully employed, and some can hardly be regarded as moderately well employed. Exception must be made of bar and rod mills and of wire-drawing departments, which are under pressure.

The present condition, of there being a scarcity of raw steel, relative to supplies for the steel-making departments, and capacity for converting ingots into merchantable material, is due in part to the abnormal character of a part of the present demand for steel. In the first place, a large tonnage of steel is being produced under stringent specifications as to cropping, whereby the tonnage of steel rolled, in proportion to the tonnage of ingots produced, is reduced. In the second place, there is a heavy demand for forging billets, to be used in the manufacture of large shells, and thus steel is taken that ordinarily would be rolled beyond the billet form.

It is possible that the output of steel ingots from the steel-making facilities in employment is less than it would be were demand of its usual character. The necessity of making much steel of special grade may prolong the time in the case of open-hearth heats and may possibly reduce the tonnage per heat. Not enough is known to justify the making of a generalization.

Expositions and Exhibits

There is nothing more effective to drive home a lesson than a direct appeal to the senses. What no amount of lecturing can accomplish is often easily impressed on the mind through the eye which sees, admires and understands, and it is this combination of the perception of beauty with instruction which makes the success of expositions.

No one who has seen the San Francisco Exposition can have escaped the sorrowful reflection that so much beauty shall soon be gone forever. Yet expositions are essentially ephemeral. They come and go like thieves in the night. A permanent exposition seems an impossibility; it surely is if it is to be self-supporting. While the success of an exposition cannot and should not be measured by dollars and cents, yet the financial success or lack of success is at least

one pretty safe indication whether or not an exposition has fulfilled its higher missionary function. To be a financial success an exposition must be limited in time; it should be long enough to be seen by all who should be interested, and short enough to reduce the operating expenses to a minimum. This period of time must be correctly judged and will vary from case to case. To limit the highly successful Chemical Exposition in New York City last week to six days, seems to have been exactly right, although we have heard more than once an expression of regret that the show would be over so soon. And what is true for expositions in limited fields is just as true for "world's fairs."

But what is true for expositions is not necessarily true for the exhibits. An exhibit can be made permanent under normal conditions and should be made permanent, if this is possible. It is true, a fine exhibit can be set up quickly by the right man; Dr. Doremus showed this in arranging single-handed in a few days the really pretty little historical and technical exhibit for the American Electrochemical Society booth at last week's chemical exposition; it is a pity that this exhibit could not be made permanent because it had been obtained by loan from many sources. But most other exhibits can be made up with a view to permanency. It is unthinkable that the wonderfully instructive exhibit of the United States Steel Corporation at San Francisco should not be preserved permanently and used over and over again at different places as an almost inexhaustible source of instruction. What magnificent results can be obtained if an exhibit is built up with a view to permanency and gradually perfected, is shown by the exhibit in the Canadian Building in San Francisco which has elicited and will always elicit so much truly deserved admiration. This is a lesson which the average exhibitor at expositions has still to learn. The fine exhibit of the different government bureaus at the Chemical Exposition had been specially prepared for this occasion, but it could and should be kept together as a nucleus for future extension.

A New Agricultural Use for Sulphuric Acid

Is agriculture about to derive a new benefit from the application of sulphuric acid to alkali soils? And can the smelter foresee a partial outlet for a product, one of the constituents of which has caused him vexation and expense at the hands of the prospective beneficiary? And is chemical research on the eve of demonstrating another instance of the interdependence of widely different industries, through the conversion of a waste product of the one into a substance useful to the other? An affirmative answer to these queries is suggested by the results of two years of investigation by Dr. C. B. Lippman, of the University of California.

At one of the sessions of the recent San Francisco meeting of the American Institute of Mining Engineers, Dr. Lippman explained the nature and results of his investigations, and illustrated by photographs the ap-

parent beneficial results obtained by applications of sulphuric acid to alkali soils. The views showed crops growing on test plots that had received from $2\frac{1}{2}$ to $7\frac{1}{2}$ tons sulphuric acid per acre, the ground being otherwise unfit for agricultural purposes on account of the concentration of alkali salts. One effect of the acid is to cause a shrinkage of the colloids, giving a better opportunity for aeration of the soil and circulation of moisture, and creating more favorable conditions for the activity of nitrifying bacteria.

An important feature of the work from the metallurgical standpoint is the quantity of acid used, running into tons per acre. From the agricultural side there is prospect of rendering useful a vast acreage of ground in the Western States, now lying waste and shunned by the farmer. Here is prospect of co-operation for mutual good between interests that have regarded each other with suspicion and enmity. The smelter may yet prove to be one of the agents for making the desert blossom as the rose.

By-Product Coking

The rapid substitution of the retort for the beehive process of making coke in the iron industry that is occurring at this time may be looked upon as a metallurgical triumph, but it is really a financial achievement. Success from a technical standpoint occurred years ago in the manufacture and use of retort coke as the iron blast furnace fuel, and the building of by-product coking plants at the present time is proceeding chiefly in accordance with the quantity of funds available. In the circumstances the increase year by year in the proportion of by-product coke manufactured is slow rather than rapid. The growth is a function of the earnings of the iron and steel producers rather than of the economies assured by the process. Probably it would be difficult to find an engineer in any industry who would not insist that his employers or prospective clients were particularly slow in investing their capital in improvements promising economy, but the whole history of the iron and steel industry shows how it is continually demanding more and more capital. At the present time the industry is investing more of its funds in by-product coking plants than in any other single item.

The growth in by-product coke production is really slow. Last year was no criterion, as iron production was small and slightly less by-product coke was made than in 1913, while there was concurrently a large decrease in the beehive production, whereby the 11,219,943 net tons of by-product coke made in 1914 comprised 32.5 per cent of the total coke output, while the 12,711,700 tons of by-product coke made in 1913 comprised 27.5 per cent of the year's coke output. One-half as much by-product coke was made in 1909 as in 1913, one-fourth as much in 1905 and one-eighth as much, approximately, in 1902, showing successive doublings in three, four and five years respectively.

Of the total coke produced, as reported by the Geological Survey, which does not take account of gas-house coke, fully 80 per cent is consumed in the man-

ufacture of pig iron, and thus the matter of replacing the beehive oven with the retort oven is chiefly the concern of the blast furnace. In view of the fact that the gas can be profitably employed in the steel works it is at the blast furnaces of the steel works more than at the merchant blast furnaces that by-product ovens are being built. A further differentiation can be made, that the consumers who have beehive ovens have been less disposed to build by-product ovens than those who have had to purchase their coke in the open market. Connellsville coke has frequently sold at very low prices, but it has always advanced to a very high level when there was a heavy demand, often doubling in price. The buyer has therefore paid more than the apparent average price, because he bought more high priced coke than low priced. Of late the building of by-product ovens has proceeded more rapidly than the erection of blast furnaces, a circumstance that has prevented the coke market from experiencing its usual sharp advance at this time when the production of pig iron has become very heavy.

It may be estimated that there are now being built, or definitely projected, by-product ovens having an annual capacity of about 4,000,000 tons, and as it is usually not far from a year from the inception of the enterprise to the actual production of coke the rate of growth in output is at the moment at the rate of not far from 4,000,000 tons annually. The present capacity seems to be somewhat under 15,000,000 tons, while as closely as can be approximated the coke requirements of the existing blast furnaces, if they were required to operate at capacity, would be about halfway between 40,000,000 and 45,000,000 tons. Even with the completion of the present new construction, therefore, the iron industry will not have accomplished one-half its task of arranging to supply itself with by-product instead of beehive coke. The remainder of the operation will be carried out largely as funds become available. The incentive to invest capital in this manner will in general be less in the future than it has been in the past, for the reason that thus far by-product ovens have been built chiefly by interests that had been buying coke, or were building blast furnaces in excess of their present coking facilities. In a short time there will be few blast furnaces using beehive coke except those that produce it themselves, or detached merchant furnaces to which the capital outlay would be somewhat disproportionate to the size of the present investment. It is to be expected, however, that even the furnace interests that have beehive ovens will gradually abandon them in favor of retort ovens located alongside the furnace.

Of course, the principal single stimulus which has caused this rapid development in by-product oven construction is the cutting off by the war of the importations of the coal-tar distillation by-products for which there is such an urgent demand by the chemical and allied industries. Just now it pays very well to invest in by-product coke ovens not for the sake of the coke, but for the sake of the by-products. But this is another story which may be reserved for another time.

Readers' Views and Comments

The Electric Furnace in the Foundry

To the Editor of Metallurgical & Chemical Engineering:

SIR:—I have read with considerable interest the paper entitled "The Electric Furnace in the Foundry," written by Mr. Wm. G. Kranz and to be presented at the San Francisco meeting of the American Institute of Mining Engineers, which appeared in the Sept. 1 issue of METALLURGICAL & CHEMICAL ENGINEERING. I have forwarded a copy of this discussion to the secretary of the American Institute of Mining Engineers for presentation at the San Francisco meeting (Sept. 16 to 18).

I agree perfectly with Mr. Kranz that steel for castings made in an electric furnace is not because of that fact all necessarily good steel, and also that the qualities which he mentions, such as absence of segregation, elimination of sulphur, great tenacity, etc., can be obtained in an electric furnace if operated under proper metallurgical conditions.

An unusually low content of sulphur in steel for castings is not, of course, an absolute necessity and the range of this element usually obtained in steel made in basic open-hearth furnaces is sufficiently low to meet all physical requirements.

The main factor in making steel for castings regardless of the process is the complete deoxidation of the bath to prevent the formation of segregation and also increase the physical qualities of the steel. Such complete deoxidation is accomplished in basic electric furnaces by holding the metal sufficiently long in the presence of a blanket of carbide of calcium, as in the Heroult or Stassano process or by the addition of 50 per cent ferrosilicon, as in the Girod or induction furnace process. However, if steel is as completely deoxidized in the furnace that when, as pointed out by Mr. Kranz, an addition of aluminium or titanium is made the added metal will not oxidize but will be found in the metallic state in the steel, there can be no doubt that such steel will reoxidize during the tapping of the furnace and also during the teeming from the ladle into the molds.

While Mr. Kranz has undoubtedly through inadvertence failed to mention the fact, it is probably the practice at his plant to add aluminium in the ladle during the tapping of the furnace to completely deoxidize the steel.

If, as I assume, it is therefore a necessity under any circumstances to complete the deoxidation of the steel in the ladle, while appreciating the fact that an electric furnace properly controlled must give a more completely deoxidized product in the furnace than it is possible to obtain in such oxidizing processes as open hearth and converter, I still question its great advantage if it is still necessary to complete the deoxidation in the ladle.

In the schedule below I have reproduced Table No. 1 showing the comparative properties of electric and basic open-hearth steel as printed in Mr. Kranz's paper, and also the results of samples from six heats of basic open-hearth and converter steels of approximately the same chemical composition.

These six analyses are representative of the quality of thoroughly deoxidized steel produced under good foundry practice, and it will be noted that the physical properties compare very satisfactorily with those of the electric steel reported by Mr. Kranz.

Mr. Kranz mentions that "absence of segregation and oxides has been firmly established by a great many

TABLE I.

	Elastic Limit	Ult. Str.	Elong.	Red	C	Mn	Si	S	P	
Electric steel..	36,400	65,300	36%	55%	.24	.52	.25	.019	.010	Referred to by Mr. Kranz
O. H. Basic....	34,800	63,000	29.5	35	.23	.53	.24	.038	.011	
O. H. Basic....	40,900	70,400	35.9	56.3	.24	.55	.30	.020	.020	Test piece unannealed
O. H. Basic....	36,200	64,200	35.9	61.3	.23	.51	.35	.020	.012	
O. H. Basic....	35,800	68,300	35.9	61.4	.23	.77	.34	.027	.012	
O. H. Basic....	38,700	61,600	35	54.0	.19	.56	.22	.027	.014	
Converter Steel	38,000	69,200	32	53.6	.21	.76	.37	.035	.041	
Converter Steel	40,500	71,000	32	52.8	.21	.68	.34	.032	.044	

investigations in our chemical and physical laboratories," and states as a proof of this fact that when ferrotitanium or aluminium is added to their electric steel either of these metals will be found as much in the steel, indicating that no oxides were present which would cause their oxidation.

I am inclined to believe that many metallurgists will be interested to obtain full details in reference to this particular point made by Mr. Kranz. Personally, I have made hundreds of heats of steel in the same type of furnace which he is using. In many of these heats 0.10 per cent titanium was used, and in no case have ever traces of titanium been found in the finished casting.

At other times I have used aluminium in the ladle and occasionally adding it into the stream of steel as it flowed from the ladle into the folds, particularly at the end of the operation, because this addition of aluminium was judged necessary to insure the soundness of the castings. In no case has aluminium been found in the finished casting, but in every case where an examination has been made for it the presence of alumina, the oxide of aluminium, has been established both by chemical and microscopical means.

I am of the opinion that what Mr. Kranz has reported as aluminium in the steels which he has treated with that metal, is in reality alumina, and I believe that more complete information on this particular point will interest metallurgists generally.

N. PETINOT.

Titanium Alloy Manufacturing Company,
Niagara Falls, N. Y.

Britannia Linings for Hardinge Mills

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In the interesting article in your August issue by H. C. Parmelee, on the Caribou mill in Boulder County, Colorado, he refers to their experience with Britannia lining for Hardinge mills, which seems to have been wholly unsatisfactory. A later experience with the same material at the Mary Murphy mill suggests that the condemnation at the Caribou mill may have been premature.

Having adopted the use of 2-in. manganoid steel balls instead of pebbles for our 4½-ft. mill, because of the increased capacity thereby obtained, we soon found that the life of the silix linings which we had been using theretofore was unduly reduced by the use of the steel balls.

We planned to try chrome steel lining, but as this would take a long time to make and deliver, we decided to use a Britannia lining in the meantime.

We obtained some of the discarded pieces of rail from the Caribou plant, which on arrival proved to be considerably worn and smooth at the edges, showing that when formerly used the mills had been run for a long time

after the lining had given way. The pieces of rail were, furthermore, encrusted with cement in places, which could not be completely removed by chipping without unwarranted expense. Owing to these conditions, the lining hardly had a fair chance.

The pieces of rail were embedded in a mixture of two parts sand to one part cement, fitted as closely as possible, and left to harden seven days. The work of lining occupied five days, as only one section could be completed at a time.

After being in use, the portion around the manhole gave some trouble at first by becoming loose. To overcome this we drove in worn balls into the interstices between the rails, hastening the process of wedging with balls which would no doubt have taken place naturally sooner or later.

Since that time the mill has been in operation ninety days, during which it has ground approximately 2500 tons of very tough ore, and it looks as if the lining will last from thirty to sixty days yet. Had the rails furnished to us been hardened as Hardinge recommends, the life of the lining would have been still greater.

In our judgment, apart from the loss of time in lining, the Britannia lining answers very well indeed. Its installation would be considerably facilitated by bolting rings around the manhole and at both ends, to which the rails might be wedged tight. If this were done, we believe there would be no difficulty whatever, with ordinary care, in getting the lining to stand. Another improvement would be to use progressively shorter pieces of rail to line the conical ends.

In our opinion, the principal drawback of the Britannia lining is the wasted space, because of which, and of the time required for lining, we do not expect to adopt it for the Hardinge mills at the Mary Murphy.

The difficulty at the Caribou mill, as to the 6-ft. Hardinge, may have been due to the very heavy balls in use there (5 in. in diameter).

Denver, Colo.

GEORGE E. COLLINS.

Niagara Falls Section of the American Electrochemical Society

(From Our Special Correspondent)

The organizing meeting of the Niagara Falls Section of the American Electrochemical Society commenced with reasonable promptness at 8 h. 0 m. 30 s. p. m. on Sept. 16. Mr. F. A. J. FitzGerald, whose protests were drowned by cries of "Oh, go ahead, be a sport!" was railroaded into the office of temporary chairman which he filled in a more or less desultory manner throughout the evening.

The minatory tones of the secretary, Mr. A. T. Hinckley, prevented any opposition to his proposal that his own minutes be accepted without reading, and Mr. Acheson Smith reported the minutes of the organizing committee, and asked for comments or criticisms on the proposed by-laws. As everybody likely to protest had been put on the organizing committee, no one, naturally, had any to offer, and Mr. Acheson Smith then reported the following nominations on behalf of the nominating committee: President, F. A. Lidbury; vice-president, L. E. Saunders; secretary, A. T. Hinckley. Someone moved that Hinckley cast one vote for himself and the rest; he blushed and did.

At this point the chairman got so fidgety that it was thought advisable to adjourn the meeting, and, the president and vice-president elect arriving at this junction, a "business session" was thereupon held at the Hotel Imperial, where the executive committee might have been seen at one end of the long table fixing plans for raising the wind—and other things.

The following telegram was sent to President Addicks of the American Electrochemical Society at San Francisco: "The Niagara Falls Section at the conclusion of its organizing meeting sends best wishes to the parent society for as lively and successful a meeting as its own sessions promise to be."

On Tuesday, Oct. 12, the section will get down to business. Operating men, power-plant engineers and, as is hoped, some eminent designers of transformers will, under the seal of the confessional, speak to each other on the subject of "Transformers for Electric Furnace Work" with as much politeness as is consistent with frankness and truth.

The Western Metallurgical Field

State Licenses for Colorado Ore Buyers

In accordance with the provisions of a bill passed by the last Colorado Legislature, effective Nov. 1, all individuals or companies engaged in ore-buying in the State are required to take out a license at a cost of \$100 per annum. The bill had its inception with Cripple Creek operators who have long sought some effective means of preventing "high-grading" by alleged assay offices and other places for disposing of stolen ore. By requiring all ore buyers to take out licenses and keep accurate records of their purchases, it is hoped that illicit buying of rich ore will be minimized. Legitimate reduction works already keep careful records of the source of the purchases, and the additional requirement of a \$100 license fee is probably cheerfully accepted by them in the interest of the mining industry. As in most cases of such legislation, some individuals buying ores and similar materials in a legitimate way will find the annual fee a burden. Annual losses from the stealing of rich ore in such camps as Cripple Creek run into enormous sums which the present legislation hopes to divert into legitimate channels.

Heavy penalties in the nature of fines and even of prison sentences can be imposed for convictions under the law.

Safety and Efficiency Engineering at Colorado School of Mines

The opening of the Colorado School of Mines for the regular fall session was marked by the dedication of the Joseph A. Holmes chair of Safety and Efficiency Engineering, a new department established in memory of the late director of the Bureau of Mines. Governor Carlson made the dedicatory address and the exercises were attended by members of the State Industrial Commission, which is charged with the administration of workmen's compensation in Colorado. State officials and engineers have evinced a keen interest in the establishment of this new chair through the initiative of Dr. William B. Phillips, president of the school. It stands not only as a fitting memorial to a man who devoted the best years of his life to the promotion of safety and efficiency in the mining and metallurgical industries, but also as an active means for training young engineers in those two paramount features of modern industrial work. No appointment has yet been made to the new professorship, but it is expected that Dr. Phillips will shortly recommend a suitable man for election by the trustees. The necessary equipment will be purchased and the courses of study correlated with those of the other departments. In addition to the work of instruction at Golden, it is expected that subsequent developments will bring the new department into close relations with operators, miners and millmen throughout the State.

New Club House for Employees of Nevada Consolidated Copper Company

The accompanying illustration shows the new club house under construction at McGill, Nev., for the employees of the Nevada Consolidated Copper Company. The building is being erected and furnished by the company, and when completed will have the usual club features. In the basement there is a large swimming pool and shower baths, bowling alleys and locker rooms. The first floor will be devoted mainly to a general lounge, reading room and library, with one large room set apart for a gymnasium. On the second and third floors there are thirty-three living rooms that will be furnished and rented to single men in the company's employ, exclusive of the members of the technical staff for whom quarters have already been provided. The average monthly rental will be about \$10 per room. A few of the rooms have private bath, but on each floor there is a large bath and toilet room for general use.

The club will be for the use of all employees without distinction or restriction except as to hours designated for certain groups of men and members of their fam-



EMPLOYEES' CLUB HOUSE, NEVADA CONSOLIDATED COPPER COMPANY

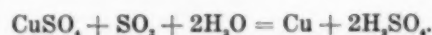
ilies. The establishment of this club is an evidence of the growing sentiment in favor of welfare work among the employees of large companies, especially in isolated places where opportunity for recreation is limited.

Weidlein's Copper Process

Some interesting experimental work in copper hydrometallurgy is in progress at the Mason Valley smelter at Thompson, Nev., under the direction of Dr. E. R. Weidlein. Particular novelty rests in the method of precipitating copper from solution and in the concentration of sulphur dioxide from smelter fume or other dilute sulphurous gases.

The method of treatment is applicable to either carbonate or sweet-roasted sulphide ores of copper. Sulphuric acid is the solvent used. Ore that is readily leachable is treated in vats; but for finer material a six-step Dorr classifier has been used with counter-current flow of solution.

Before precipitation the solution is neutralized with lime and treated with sulphur dioxide until it has dissolved a percentage of gas equal to that of the contained copper. Precipitation of metallic copper ensues instantly when this solution is brought to a temperature of 160 deg. C. under a pressure of 100 lb. The precipitated metal is finely crystalline and when melted assays over 99 per cent pure. In the process of precipitation, sulphuric acid is regenerated in twice the quantity originally present in combination with copper:



The mechanical arrangements are such that the processes of dissolution and precipitation are continuous. Heat is conserved by returning the hot precipitated solution through a heat exchanger in counter current to the flow of fresh solution to the precipitator. The latter is a lead-lined cylinder through which the solution flows from bottom to top. The necessary temperature is obtained by circulating oil of high flash-point from a heater through the jacket surrounding the lead lining. Precipitated copper is discharged through a bottom gate into a receptacle from which it is periodically removed, washed and melted.

An interesting development of Dr. Weidlein's research, and one of prospective economic importance, is a process of concentrating the sulphur dioxide from smelter fume or other gases weak in that constituent. The details of the method are not now available, but it depends on the principle of selective absorption in a tower packed with the absorbent. The gas can be driven from the absorbent by heat and used as desired.

Some of the research work in connection with this process has been conducted at the Mellon Institute, Pittsburgh, in conjunction with the large-scale experimental work at Thompson, Nev. The investigations have been carried on in a careful and scientific manner, and the announcement of results will be awaited with interest, in view of the probable future importance of hydrometallurgy for low-grade, oxidized ores of copper.

First-Aid Field Meet at San Francisco

The contests in first-aid and rescue work held at the Exposition grounds in San Francisco, Sept. 22, 23 and 24, formed an interesting feature of "Mining Week" at the Exposition. Twenty-six first-aid teams and fifteen mine-rescue teams were entered, representing eighteen States. The contest events were selected by the judges from lists that had been previously placed in the hands of the teams for practice purposes. In first-aid there were events for one man, two and three men and full team. For coal-mine rescue events an explosion was simulated in an improvised gallery. The meet was financed by the California Metal Producers Association, which subscribed \$1,500. Prizes for successful contestants included silver cups, silver and bronze medals, and miscellaneous donations from numerous manufacturers.

American Mining Congress

The eighteenth annual session of the American Mining Congress was held at San Francisco, Sept. 20-22, to receive reports of important committees and discuss topics of interest to the mining industry. Mr. Van H. Manning, director of the Bureau of Mines, outlined the past services of the Bureau to the mining industry and suggested a number of lines of metallurgical research in which work will be done in the near future. Among some of these problems are the recovery of platinum and allied metals, the improvement in recovery of zinc from low-grade ores, and the development of our resources in tin, chromium, manganese, antimony and molybdenum, by improving methods for handling low-grade material. Dr. George Otis Smith addressed the Congress on the subject of "Plain Writing," with a plea for fewer razor-edged words in technical writing, suited only to hair-splitting technicalities. The subject of mining and metallurgical education also received attention in a paper by Prof. Charles F. Willis of Tucson, Ariz. The balance of the program was devoted to business and economic aspects of mining.

Memorial exercises in honor of Dr. Joseph A. Holmes, late director of the Bureau of Mines, were held at noon, Sept. 21.

The Iron and Steel Market

Another month's developments in the course of the iron and steel market has indicated still more conclusively that the backbone of the steel demand is the requirements for war purposes. The war demand has continued to increase, and as fresh orders for large tonnages are placed from day to day, while purchases formerly made were for extended deliveries, the output of war material is steadily increasing.

The general alignment of demand has become more clearly defined. In no finished steel product is there a large domestic demand. For war purposes there is a very heavy demand for wire products, for large steel rounds and for forging billets. Inasmuch as the large rounds are rolled on rail mills, enabling the rail mills to consume more steel than for many years, while the large tonnage of forging billets demanded requires no finishing operation by way of rolling, a condition has arisen by which there is great pressure for tonnage upon the steel-making departments, and only occasional pressure upon finishing mills. At the same time it develops that there is ample pig iron for the requirements of Bessemer converters and open-hearth furnaces. There results what is called in trade parlance "a scarcity of steel." Rolling billets are scarcely to be obtained at \$26 at mill, per gross ton, when bars, plates and shapes are quoted at \$27 per net ton, and forging billets have brought \$35 and more. Between basic pig iron at valley furnace and basic open-hearth billets at valley mill there is a spread of fully \$11 per ton while last December the spread was only about \$5.

The entire open-hearth steel-making capacity of the country is in full employment, and practically the entire Bessemer capacity. The small Bessemer plant at Columbus is idle, and at a few Bessemer plants operations are not at the fullest rate possible, but such instances are exceptional. The steel trade has thus far supplied itself with pig iron without drawing nearly as much upon the merchant furnaces as in 1912 or 1909, periods in which the pressure for steel was scarcely as great as at present. Upon coke there has been no pressure at all, doubtless by reason of the large increase in coke-making capacity of late through the erection of retort plants. The demand in the market for scrap is not heavy and scrap is selling at lower prices than are usually current when billets bring their present prices. The situation doubtless is a reflection of the large ingot cropping required in the filling of many of the war orders.

All the consuming industries in the United States show a better demand for finished steel products than two or three months ago, but in no instance is the demand up to previous high levels unless the industry is engaged more or less in the production of war material. In a general sense export and war orders are synonymous, for the purchases of neutral countries are still below normal. Agricultural implement exports, while heavier than six months or a year ago, are distinctly below normal. In the machine tool and automobile industries there is feverish activity as, of course, is the case at munition factories. Exports direct and indirect are probably now consuming finished steel at the rate of more than 5,000,000 tons annually.

Pig Iron

Pig iron prices advanced about one-half as much in September as in August, and the September advances were due more to the sold-up condition of the furnaces than to any large demand. There was very little buying by foundry interests, and no general buying by steel works, though a few large blocks were taken. The

condition at the close of September is that consumers appear to be well covered against requirements through the remainder of the year, with the furnaces now in operation equally well sold up, and neither buyer nor seller anxious to force conclusions as to deliveries in the first half of the new year. A buying movement for that delivery is hardly expected before late October or early November. While the steel works are producing more steel than ever before, and the steel interests are making more pig iron than ever before, the merchant blast furnace output is considerably less than the capacity. The idle merchant furnaces are not finding occasion to blow in as rapidly as was expected and thus buyers of pig iron feel fairly well insured, at least for the present, against a runaway market.

Shipments of Lake Superior ore down the lakes amounted to 26,806,420 tons for the season to Sept. 1, or less than in the corresponding period of several preceding years, but estimates of the movement for the remainder of the season are made as high as 22,000,000 tons and if such expectations are realized the year's movement will closely approximate the record. There is no danger of anything like a general ore shortage, though buyers seeking particular descriptions of ore, especially for the open-hearth furnace, have lately had a little difficulty in effecting purchases. Pig iron is quotable as follows: No. 2 foundry delivered Philadelphia, \$16.25 to \$16.75; f.o.b. furnace, Buffalo, \$15.50 to \$16; delivered Cleveland, \$15.25; f.o.b. furnace, Chicago, \$14.25 to \$14.75; f.o.b. Birmingham, \$11.50 for prompt, \$12.50 for first half 1916; at valley furnaces, 95c. higher delivered Pittsburgh: Bessemer, \$16; basic, \$15; No. 2 foundry and malleable, \$14.50 to \$15; gray forge, \$14.25 to \$14.75.

Steel

To the insistent demand for rolling billets that characterized August, with a moderate demand for forging billets, there has succeeded a very heavy demand for forging billets. Billets are so scarce in general, and prices that can be secured for special steels are so attractive, that the market for ordinary soft steel rolling billets is scarcely quotable at all. There is no question that \$26 at maker's mill, Youngstown, would readily be paid for ordinary open-hearth billets, and Bessemer billets might easily bring \$25, prices delivered Pittsburgh being \$1 a ton higher, as no steel to speak of is being offered by Pittsburgh mills. Sheet bars would not be sold except at the full billet price or a trifle more, but there is no demand whatever. The sheet and tin mills are covered by contracts, and in any event the selling prices of their products are such that they could not afford to buy steel at prices that would be asked. Wire rods are quotable at \$30, Pittsburgh, but sellers can scarcely be found at any price.

Finished Steel

Wire products were advanced \$2 a ton Sept. 20. Effective Sept. 28 the American Sheet & Tin Plate Company advances its prices \$2 a ton on blue annealed and black sheets, to 1.6c. for blue annealed, 2c. for Bessemer black and 2.05c. to 2.1c. for open-hearth black. Bars, plates and shapes for delivery at mill convenience have been 1.35c., for 1.40c. has been quoted and done on first quarter contracts and the mills have little left to sell for earlier delivery so that the market promises shortly to be squarely on the basis of 1.4c.

Current quotations, f.o.b. Pittsburgh, unless otherwise noted:

Rails, standard section, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.35c. to 1.4c.

Shapes, 1.35c. to 1.4c.

Steel bars and bands, 1.35c. to 1.4c., base; hoops, 1.5c., base.

Iron bars, 1.45c. to 1.5c., Pittsburgh; 1.509c. to 1.559c., Philadelphia; 1.35c., Chicago.

Sheets, blue annealed, 10-gage, 1.55c. to 1.6c.; black, 28-gage, 2c. to 2.1c.; galvanized, 28-gage, 3.5c. to 3.6c.; painted corrugated, 28-gage, 2.2c.; galvanized corrugated, 28-gage, 3.55c. to 3.65c.

Tin plate, \$3.10 to \$3.20 for 100-lb. coke.

Steel pipe, $\frac{3}{4}$ to 3-in., black, 79 per cent off list; galvanized, 63 $\frac{1}{2}$ per cent off list.

Steel boiler tubes (less than carloads) 72 per cent off list.

Structural rivets, 1.6c.; boiler rivets, 1.7c.

Railroad spikes, 1.5c., Pittsburgh; 1.65c., Chicago.

The New Director of the Bureau of Mines

Mr. Van H. Manning has been appointed Director of the U. S. Bureau of Mines, as successor of the late Joseph A. Holmes. During Dr. Holmes' administration of the bureau, Mr. Manning was Assistant Director. Before entering the Bureau of Mines he was connected with the U. S. Geological Survey. The good wishes of the profession and the industry are due to Mr. Manning on his entrance into a position of grave responsibilities and great opportunities.

San Francisco Meeting of American Electrochemical Society

The twenty-eighth general meeting of the American Electrochemical Society was held in San Francisco from Thursday to Saturday, Sept. 16 to 18. The attendance was comparatively small on account of the scarcity of local members and electrochemical industries in California, but it came up to expectations, and those who were present enjoyed the meeting immensely.

At the Board of Directors meeting routine business was transacted and it was decided to hold the Spring meeting, 1916, at Washington, D. C.

The technical session of Thursday morning was opened by President Addicks and the papers by Wills and Schuyler, Snyder, Mott, Aldrich, Betts, Bennet, Rose and Tinkler, Frederiksen, Bancroft, and Bosworth were read and briefly discussed.

On Friday two sessions were held as planned. In the morning session held jointly with the American Institute of Mining Engineers, the papers by Lyon and Keeney, Clevenger, Addicks, Wile, Boeck, Davy, Goodrich and Pyne were read and discussed at some length.

The afternoon session was held in conjunction with the American Institute of Electrical Engineers and the papers by Foster, Sebast, and Beckman were read and discussed.

We reserve a full account of all the papers and discussions for our next issue.

A pleasing feature of the meeting was the session at which the Exposition medal was presented to the Society. Mr. Chas. Butters presided on this occasion. Mr. Chas. A. Vogelsang presented the medal.

President Addicks accepted the medal with a short address in which he referred to the westward trend of electrometallurgy. He traced the historical development from the invention of the dynamo with its effect on mechanical and electrical engineering and on chemistry and metallurgy to the ultimate birth of electrochemistry as a distinct science and industry which necessitated the formation of a new society for growth and expansion. Electrochemistry has played an important part in the industrial progress of recent years,

which the San Francisco Exposition expresses on such a magnificent scale. The presentation of the medal was followed by special visits to the exhibit of the Bureau of Mines and the Norway exhibit of nitrate products.

All social functions were carried out according to the program and greatly enjoyed.

San Francisco Meeting of American Institute of Mining Engineers

The 111th meeting of the American Institute of Mining Engineers, held in San Francisco from Sept. 16 to 18, was most successful. The attendance was large in the technical sessions as well as at all social functions. Great credit is due to the different committees and their chairmen, Merrill, Hanks, Shockley, Clevenger, for the excellent arrangements made. An elaborate souvenir program with artistic illustrations of California and the Exposition had been prepared. All meetings were held at the Bellevue Hotel.

At the opening meeting on Thursday morning in the Palm Room of the Bellevue Hotel, C. W. Merrill presided. An address of welcome to California was made by Arthur Arlett. President Saunders replied for the Institute. Dr. L. D. Ricketts then presented his address on some problems of copper leaching. A. J. Clark spoke on Homestake metallurgy, and F. L. Bosqui on gold metallurgy in the Witwatersrand district. The latter paper brought out considerable discussion of a reminiscent nature from former Rand operators.

In the afternoon session on gold and silver F. Lynwood Garrison presided, and papers by C. W. DeWitt, W. P. Lass, E. E. Carpenter, N. Herz, E. B. Thornhill, J. A. Carpenter, W. J. Sharwood and A. H. Jones were read. Simultaneously a session on geology and mineralogy was held, Andrew G. Lawson presiding.

On Friday morning a joint session was held with the American Electrochemical Society, Lawrence Addicks presiding. Simultaneously there was a session on petroleum and gas, with Arthur F. L. Bell in the chair. In the afternoon there was a session on mining, milling and non-ferrous metallurgy.

Abstracts of the papers and discussions are reserved for our next issue.

On Friday afternoon the Exposition medal was presented by the Exposition authorities to the Institute. President Saunders accepted the medal with a felicitous speech.

The banquet on Friday night at the Palace Hotel was a brilliant affair, attended by some three hundred members and friends of the Institute. The occasion was graced by the presence of many ladies. Mr. E. H. Benjamin acted as toastmaster and speeches were made by Benjamin Ide Wheeler, "An Engineer"; W. L. Saunders, "California"; Van H. Manning, "Co-operation"; George Otis Smith, "The Outlook," and T. A. Rickard, "The Ladies."

On Saturday morning a boat trip was made around San Francisco Bay on the private yacht Cyprus, by courtesy of Mr. D. C. Jackling. A stop was made at the Selby Smelter, where the blast furnaces, the Parkes refining process, the Cottrell process for precipitation of sulphuric acid fume from parting vats, the filtration of smelter gases in a bag house and the manufacture of special lead products were shown. For Sunday afternoon Mr. and Mrs. Charles Butters had invited the Institute to their Oakland home for a lawn reception and tea, and inspection of laboratories and testing plant.

The Institute may be proud of the great success of this meeting.

Metallurgy at International Engineering Congress

San Francisco, September 20 to 25, 1915

The International Engineering Congress, held at San Francisco from Monday to Saturday, Sept. 20 to 25, 1915, was a great success from start to finish.

At the opening session on Monday the attendance was 800, with a good representation from foreign countries.

Mr. W. F. DURAND, chairman of the organization and managing committee, opened the Congress with a review of the four years of work, the object of which was now being realized. The local committee had corresponded with 250,000 engineers and 250 engineering societies. Although the European war had threatened to impair the success, the value of the Proceedings of the Congress has not been impaired in any way. Two hundred papers have been printed in advance; thirty more papers are yet to be printed. The Proceedings of the Congress will fill eleven volumes of 7000 pages, and the authors will represent eighteen countries. Mr. Durand concluded by introducing the Honorary President General GOETHALS, who, after acknowledging the honor, introduced the Mayor of San Francisco.

Mayor JAMES ROLPH, JR., welcomed the Congress to San Francisco and paid a high tribute to all classes of engineers for constructive work on the Panama Canal, of which San Francisco is the chief beneficiary.

President CHARLES C. MOORE of the Panama-Pacific Exposition said this Congress was by far the most important of 880 different conventions held in connection with the Exposition and expressed the hope that the deliberations of the Congress would result in vast good for humanity.

General GOETHALS then made his formal address on the Panama Canal and the Panama-Pacific Exposition. The completion of the canal was possible only through the coöperation of all classes of engineers and scientists. Incidentally it proved that engineers are fitted for great executive administrative work when politics is eliminated.

Brief responses to the address of welcome were made by the delegates of Sweden, Switzerland, France, Cuba, China, Japan, Netherlands, Nicaragua, Spain, Canada and Guatemala.

The presentation of the John Fritz medal to Dr. James Douglas, which was to conclude this session, had to be postponed on account of the illness of Dr. Douglas.

The real work of the Congress was carried out, of course, in the different sections. In the following we report the proceedings in the Section on Metallurgy:

TUESDAY SESSION

The first session of the Metallurgical Section was held on Tuesday afternoon, Prof. Richards presiding. It was almost completely devoted to the Symposium on Iron and Steel.

Symposium on Iron and Steel

The Symposium on Iron and Steel had been arranged and edited by Dr. HENRY M. HOWE.

The first paper presented related to iron and steel castings, the author being Mr. JOHN HOWE HALL of the Taylor-Wharton Iron & Steel Co. of High Bridge, N. J. Iron and steel castings may be made either of steel or of malleable iron or of cast iron. According to the general nature of the three metals, the castings have distinct fields of usefulness.

The variations in the properties of steel castings are due (1) to variation in the composition of the steel, (2) to the annealing or heat treatment to which the steel is subjected, and (3) to the soundness of the casting.

The soundness depends on the degree to which blowholes or shrinkage cavities can be avoided. As to composition the effect of carbon, silicon, manganese, phosphorus and sulphur was discussed, also the effect of annealing and heat treatment on steels of different composition.

The method by which the steel is made influences its properties largely by its effect upon the composition that it is possible to secure and upon the tendency of the steel to unsoundness. The extent to which the steel is subjected to oxidation during its manufacture influences the tendency to unsoundness. In general, the Bessemer process oxidizes the steel to the greatest extent, the open-hearth process to a less degree, the crucible process to a still less degree, and the electric furnace process least of all.

The process by which the steel is made is, in many cases, of less importance than the skill and knowledge of the workmen, so that the purchaser is better protected by calling for metal of good properties as exhibited by tests than by buying castings made by some particular process that he supposes to be the best. Even electric-furnace steel is subject to this statement. The growing use of the electric furnace in steel foundries is due as much to the fact that it possesses certain technical advantages for the manufacture of high-grade small castings as to the superior excellence of the steel made in it. "The electric furnace, so far, has been used in competition with the Bessemer and crucible processes in making light work, for which it has certain marked advantages. One may hazard a guess that its chief application in the future will be in this field, and that its use for heavy work will be confined to a limited number of cases where steel of very high quality is required."

Malleable iron castings and cast iron castings were finally briefly discussed.

"The best way to secure satisfactory castings is to prescribe the tests that the metal must meet—such as strength, ability to withstand a certain hydraulic pressure without developing leaks, machinability, etc.—and leave the composition to the maker, who can generally be depended upon to choose the composition best suited to the requirements. The maximum sulphur, and sometimes phosphorus, content, may be specified, but the engineer should be careful not to go so far in this line as to unnecessarily embarrass the foundryman."

In the discussion which followed, Mr. Bechman said the trade term "semi-steel" should be eliminated, as it offered a chance for imposition on the consumer by suggesting something better than the actual product. The possibility of including radiographic tests of castings in the specification was pointed out.

Metallography and the Hardening of Steel was the subject of a paper by Dr. ALBERT SAUVEUR of Harvard University. The influence exerted by metallography on the elucidation of the still much debated question of the causes underlying the hardening of steel was pointed out. The author discussed the phlogiston theory, Percy's explanation, Akerman's compression theory,

Howe's explanation in 1890, early tension or stress theory, Osmond's allotropic theory, the stress theory again, Le Chatelier's theory, Arnold's subcarbide theory, McCance's interstrain theory, Humphrey's amorphous theory, and Carpenter's and Edwards' twinning and amorphous iron theory.

The many recent attempts at arriving at a satisfactory explanation of the hardening of steel are based on one or more of the following conceptions (1) existence of a hard allotropic variety of iron, (2) existence of solid solutions involving the occurrence of so-called "hardening" carbon, and (3) existence of strains in quenched steel causing or not an amorphous condition in the iron. No theory so far presented fully satisfies our craving for a scientifically acceptable explanation of the many phenomena involved.

"It would seem as if the methods used to date for the elucidation of this complex problem have yielded all they are capable of yielding, and that further straining of these methods will only serve to confuse the issue, a point having been reached when this juggling, no matter how skillfully done, with allotropy, solid solutions, and strains is causing weariness without advancing the solution of the problem. The tendency of late has been to abandon the safer road of experimental facts and to enter the maze of excessive speculations, in which there is great danger of some becoming hopelessly lost. The conclusion seems warranted that new avenues of approach must be found if we are ever to obtain a correct answer to this apparent enigma."

The discussion of this paper showed that the consensus of opinion was in favor of Le Chatelier's theory, although it was admitted that it would not explain all varieties of steel. Radiography was again suggested as a possible new method of attack to distinguish between different steels.

The Recent Progress and Present State of the Technical Application of the Case Hardening of Steel was the subject of a long paper by F. GIOLITTI, Director General of the Steel Works, Gio. Ansaldo & Co. of Genoa, Italy. The author first discusses the present condition of our theoretical knowledge of the process of case-hardening of steel. He then deals with the characteristics of the various carburizing substances and their use. He favors "gradual" agents, the activity of which is due exclusively or in absolutely preponderant degree to the specific action of carbon monoxide, as distinguished from "abrupt" agents (nitrogenous organic substances, hydrocarbons, cyanides and ferrocyanides).

"Gradual" agents are powdered or granular charcoal, calcined lampblack and calcined bone charcoal; further mixtures of powdered or granular charcoal with carbonates which are dissociated at high temperature ("Caron's cement"; sixty parts of powdered wood charcoal mixed with forty parts of pulverized carbonate of barium); further granular wood charcoal through which is circulated a more or less slow current of carbon monoxide. With the last agent the action of the carburizing substance may best be regulated.

The author then gives illustrated descriptions of the arrangement for the use of various types of carburizing materials and finally discusses the treatment and the characteristic properties of cemented parts.

There was no discussion of this paper.

The Duplex Process of Steel Manufacture was the subject of a paper by Mr. F. F. LINES of the Maryland Steel Company, Sparrow's Point, Md. The author discusses the combination of the acid Bessemer and the basic open-hearth. The acid converter oxidizes the silicon, together with the manganese and a certain portion of the carbon, the exact amount depending upon

the practice. The blow metal is then transferred to the basic open-hearth furnace where the phosphorus and the remainder of the carbon is removed. The duplex process shortens the open-hearth purification by more than five-sixths of the usual period, giving a steel of the same quality as the straight open-hearth process. Some details of operation in practice and results are given in the paper.

In the discussion of the paper, Dr. Richards said that this process was only one of many possible variations of duplexing. He expected a wider use of combination methods, using the most economic features of the Bessemer, the open-hearth, and the electric processes in combination.

Methods of Preventing Piping in Steel Ingots was the subject of a paper by Mr. EMIL GATHMANN of Baltimore, Md. After a brief discussion of Hadfield's and Kennedy's methods, the author said that an ingot with its larger horizontal cross-sectional area at the top is without question the best shape for obtaining the important so-called "lag" in solidification of the

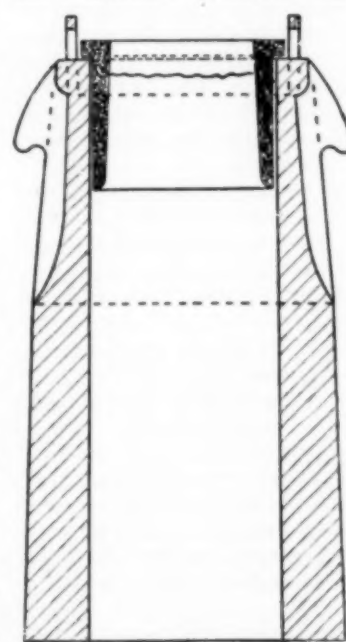


FIG. 1—GATHMANN MOLD

steel, and whenever such large-end-up ingots can be conveniently used, it is the best practice to do so. Another method of the author is now being tried at one plant of the U. S. Steel Corporation. He uses ordinary big-end-down ingots, but designs the mold so that the lower 70 or 80 per cent of the metallic mold in which the ingot is cast has a much greater degree of heat absorptive quality than the upper 30 or 20 per cent. (Fig. 1.) A metallic mold with heavy lower body walls and thin upper walls, *per se*, properly designed, will produce a sound homogeneous ingot with about a 20 per

cent top crop in split ingots of dead killed steel, which is about 15 per cent less than is usually necessary in cropping cold ingots made in the old type of mold of like grade of steel.

In the discussion of the paper the importance of following sound metallurgical principles in thorough degasification of molten steel regardless of the method of producing the ingot was pointed out.

Steel Alloys was the subject of a paper by GEORGE L. NORRIS of Pittsburgh, Pa. The paper gave compositions and special uses of steels alloyed with manganese, silicon, nickel, chromium, vanadium, tungsten, and cobalt.

Steel Making in the Electric Furnace was the subject of a paper of Mr. JAMES H. GRAY of the U. S. Steel Corporation. The electric furnace is a new instrument for steel-making, as it has a neutral and even reducing atmosphere as distinguished from the oxidizing atmosphere of all other steel furnaces.

Upward of 150 electric steel furnaces have been installed in many different countries. The largest unit so far is twenty tons.

"Electric steel is now extensively used for products as tires, axles, seamless tubes, and small castings. The

fact that electric steel lends itself to heat treatment more readily than other kinds of steel, both as regards greater range of temperature and absence of cracking in the quenched piece, and that there is less loss due to defective material after machining in the machine shop also gives this steel a preference even at a higher price.

"Many have doubted if electric steel can ever be made for such low-priced products as rails and structural material so as to compete with open-hearth steel. I believe that the solution of this problem depends upon the adoption of the proper combination process by which the roughing down work will be done by one or several of the older methods using cheap fuel, and the finishing or final refining done in the electric furnace. Both the acid and the basic Bessemer and the open hearth have been used to supply molten metal to the electric furnace. The finishing has been done in both basic and acid electric furnaces.

"In the basic electric furnace both dephosphorization and desulphurization can be performed, and it can be supplied with a metal only partially refined, while the acid electric furnace should be supplied with a metal from which both phosphorus and sulphur have been removed, requiring greater preliminary refining—going back even to the blast furnace.

"During the last two or three years rapid strides have been made with the duplex or Bessemer open-hearth process, and costs are being obtained which compensate for the excessive metal loss in the Bessemer part of the process. It may be that the duplex process in connection with either the basic or acid electric furnace will give us the solution. However, enough has already been done with the manufacture of the heavier or lower priced products to indicate that, provided it is turned out in producing units of equal size, the total cost of electric steel will be near enough to that of open hearth steel, so that the manufacturer can afford to stand the difference in order to give the consumer quality, the requirements for which are constantly growing more rigid.

"The possibility of bringing the cost of the two steels near together will appear more feasible if we consider such incidental savings as the use of cheap pig iron at the beginning of the process and the smaller discard of rolled product due to having an ingot free from segregation.

"In Germany, Luxembourg and eastern France, the electric furnace is the best apparent solution of a condition which is a menace to the steel industry of those countries.

"While the high phosphorus ores of Luxembourg and Lorraine, together with the basic Bessemer process, made possible the great steel development of Germany, the quality of basic Bessemer steel does not to-day give it a standing with open-hearth steel, while the demand for better quality is daily growing. On the other hand, basic Bessemer steel, after refining in the electric furnace, is superior to open-hearth steel. The manufacture of electric steel by this method was begun in Germany several years ago, and has in moderate quantities been made into all kinds of steel products. It seems probable that the American steel manufacturer will find it necessary to adopt electric steel to meet the competition which he will meet in the world's markets.

"It has been remarked that the progress of electric steel manufacture in America has been slow as compared with that in Europe, but the indications are that this relation will soon be reversed. It was natural that the invention of the electric furnace should be made in countries where cheap hydro-electric power was already in extensive use for other electro-chemical processes, but it was only a couple of years before the

first electric furnace was installed in the United States. We must also remember that the first large furnace, namely, one of fifteen tons' capacity, requiring electrodes 2 ft. in diameter, a then unheard of size for steel furnace use, was built here; also that this furnace was the first to use three-phase electric current, which adapted it to utilize the kind of current in general commercial use.

"There are now either built or building over forty electric furnaces in America, of which there are twenty-seven of the Heroult type alone. The average size of these furnaces is also greater than the average size in Europe.

"If the electric furnace be used for the further refining of steel made in present installations of the older processes, as now seems probable, the amount of electric steel produced should then eventually be commensurate with that now being produced by those processes; and it follows that electric steel production in the United States will exceed that of any other country."

In the discussion Mr. Beckman said that the manufacture of electric steel castings is possible at the Pacific coast, while duplexing is not possible in view of the lack of open-hearth and Bessemer plants. One hydro-electric development at the Pacific coast is able to supply 600,000 hp. continuously.

Mr. Babcock questioned the cheapness of hydro-electric power on account of the expense of the first installation and the fluctuation of the available water. He thought steam power to be cheaper but too expensive for electric furnace operation.

Mr. Beckman replied that castings are now made in the electric furnace in San Francisco, Portland, Seattle, and Los Angeles, and that four new plants are projected.

Electrometallurgy was the subject of the last paper of the session, the author being Dr. E. F. ROEBER, editor of "Metallurgical and Chemical Engineering." The author first deals with electric furnace processes, giving the fundamental principles and a classification, and discussing the chief metallurgical applications of electric furnaces for melting and refining (steel) and for reduction processes (ferro-alloys, iron, zinc). The second chapter deals with electrolytic processes; after a statement of the fundamental principles and a classification, the author discusses commercial applications of electrolytic processes with soluble anodes (electroplating, electrolytic refining of copper, silver, gold, lead, nickel, zinc, iron, tin, bismuth, cadmium) and of electrolytic processes with insoluble anodes (electrolytic precipitation of gold in cyanide process and of copper in copper leaching processes). The third part of the paper deals with electrolytic furnace processes (aluminum, sodium, magnesium, calcium, cerium, zinc).

In the discussion of the paper the possibilities of electric smelting of California complex ores was suggested.

THURSDAY SESSIONS

Symposium on Copper

The second and third sessions of the Section on Metallurgy were held on the morning and afternoon of Thursday, September 23, Dr. L. D. RICKETTS presiding.

Both sessions were devoted to the Symposium on Copper, arranged and edited by Mr. E. P. MATHEWSON, of the Anaconda Copper Mining Co.

The first paper on the program was a general statement of **Progress in Copper Metallurgy**, by THOMAS T. READ. The author reviews the shifting changes that have occurred to meet new conditions, and the resulting interest in different phases of copper metallurgy at different periods. Blast-furnace smelting developed

to its height when the mines were producing suitable high-grade sulphide ore in lump form. With the development of low-grade ore bodies and the methods of concentrating them, roasting and reverberatory-smelting furnaces became improved, and the advance in this art left blast-furnace smelting in the background. With this came the successful use of the basic lining for converters, which improved and simplified general smelting practice as well as converting itself. Later, hydrometallurgical processes received a great deal of attention, with resulting notable progress in the wet treatment of low-grade ores and tailings. This work is still in progress and, in the opinion of the author, may exert a profound effect on the metallurgy of copper.

In the discussion of this paper Dr. RICKETTS said the dust losses in reverberatory smelting likely increase with the treatment of fine flotation concentrates and must receive attention. The increase of leaching processes raises the problem of the disposal of waste acid liquor.

Advances in Copper Smelting was the subject of a paper by FREDERICK LAIST of the Anaconda Copper Mining Co. The author regards the rapid growth in favor of reverberatory as compared with blast-furnace smelting as the most notable difference between practice in the past ten years and the ten years preceding. He assigns the following reasons: The lengthening of Anaconda reverberatories together with the semi-continuous method of operation, and the reduction of cost of reverberatory smelting to the level of blast-furnace smelting; introduction of oil firing; success of pulverized coal firing; and the remarkable success of the flotation process in making high recoveries, so that concentration followed by reverberatory smelting is more profitable than direct smelting, even on comparatively high-grade material. At Anaconda, for example, the direct smelting of first-class ore is to be stopped, and all ore will be concentrated and smelted in reverberatories. This will result in economies due, in part, to the fact that reverberatory smelting with pulverized coal will be cheaper than blast-furnace smelting, and, in part, to the elimination of barren flux which must be used in blast furnaces.

Basic lining for converters has revolutionized converter practice, and it has been demonstrated that practically any size or shape of converter shell can be successfully lined and operated as a basic converter. Many of the refinements originally considered essential are not considered of vital importance. The main considerations for successful operation are (1) avoidance of too high temperature, and (2) the maintenance of a coating of magnetite over the bricks.

No radical changes of importance in blast-furnace smelting have occurred, except the building of the long furnaces by E. P. Mathewson. The use of hot blast has been abandoned. The development of the turbo blower for pressure up to 16 lb. per sq. in., may result in the displacement of the Root type of blower for blast furnace and converter air.

The McDougall type of roaster holds its place as a roasting furnace as well as a preheater for reverberatory charges where the quantity of sulphur is low and a hot-fry material is desired.

Bedding systems are growing in favor, especially where materials of diverse character are being smelted.

More attention is being paid to dust losses and the purification of smelter gases. Bag houses and the Cottrell system of electric precipitation are successfully used.

The author gives a bibliography of copper-smelting literature and brief comment on details of the foregoing general statements.

Dr. Cottrell spoke of the effect of temperature on

electrostatic precipitation and fractional separation of fume constituents by regulation of temperature. Lower voltage is used at high temperatures since the dielectric strength decreases with increase in temperature.

Dr. Ricketts said that unaccountable losses in smelting suggested the necessity of studying possible constant errors in sampling which would explain such losses.

Mr. A. E. Wells mentioned an instance of faulty moisture sampling of concentrates at a smelter, which resulted in an apparent increase of the plant copper loss by 40 per cent.

Mr. E. A. Hersam pointed out the need of more data on converter slags and linings, on the temperature of slag formation, and the composition of the acid material added to the converter.

Replying to questions Mr. Laist said that basic converting could be successfully carried out in small plants since converters could be used only for one shift daily if necessary. The basic converter stands hard usage with surprisingly little cracking of the lining due to expansion and contraction. The prospective shortage of Austrian magnesite caused the Anaconda experiments with other materials. California magnesite was found fairly satisfactory giving half the life, while chrome brick gave one-fifth the life of Austrian magnesite.

Mr. R. H. Bradford inquired concerning the possibility of sintering raw concentrates and leaving enough sulphur for blast smelting.

Mr. Laist explained that it was rather difficult to sinter high-sulphur material, on account of the clogging of the grates and distillation of sulphur. But even if Mr. Bradford's suggestion could be carried out, the cost of sintering plus blast smelting is greater than the cost of roasting and reverberatory smelting.

Metallurgy of Copper in Japan was the subject of a paper by Mr. R. KONDO, Director of the Furnkawa Co., Tokyo, Japan. It reviewed the progress of copper metallurgy in Japan since the earliest days of the Mabuki converting process. The present Japanese copper plants use modern processes of sintering, smelting, and electrolytic refining. The smoke problem is acute in Japan on account of the congested population and the bad effect of the sulphur fumes on rice.

Copper Metallurgy of the Southwest was the subject of a paper by Dr. JAMES DOUGLAS, reviewing the history and development of copper metallurgy in the southwestern states. Evidences of copper metallurgy in prehistoric times in this part of the country may be seen in the copper hammers found in shallow pits on carbonate mines. Later, adobe furnaces were used, the remains of which still stand near the Hanover mines. Apart from these primitive efforts, the first important copper mining and reduction occurred about 1872 when the Longfellow and Coronado mines were opened at Clifton and the ores smelted in furnaces of different types; first, reverberatories; then adobe stacks, and finally copper-jacketed furnaces. The latter were still used as late as 1881.

Work at the Copper Queen began in June, 1880, with a 36-in. iron-jacket furnace for smelting. A second stack of this type was erected and the plant turned out for the original Copper Queen Mining Co., from 1880 to 1885, a total of 34,536,000 lb. copper from ore averaging 11.5 per cent copper. Fortunately the mines of the Bisbee district yielded an oxidized ore of fusible composition, and slag losses were low, being about 2½ per cent. In the Clifton and Globe districts, on the other hand, where the ores were silicious and required as much as 50 per cent barren flux to render them fusible, the slags ran from 3½ to 4½ per cent copper. The introduction of Bessemer converting at the Copper

Queen in 1893 was necessitated by the increased sulphur in the deeper ores. The furnace yield increased $1\frac{1}{2}$ per cent and the grade of Bessemer to 99 per cent, fitting them for electrolytic refining.

When the new Copper Queen works were erected in the Sulphur Spring Valley, many changes and improvements were made. The blast furnaces were enlarged; basic-lined converters were adopted; a roasting and reverberatory department was added.

The most notable change in copper smelting in the southwest, as elsewhere, has been the substitution of reverberatories for blast furnaces, in order to smelt the increasing quantity of concentrates offered. At the new plant of the Arizona Copper Co., Clifton, and the American Smelting & Refining Co., Hayden, reverberatories are used exclusively. The new plant of the Interna-

blast furnaces and four converters, and was immediately enlarged to ten blast furnaces and seven stands of converters, being completed in 1907. Although larger, it still contained no reverberatories. The furnace charges were quite fine, 40 per cent passing a $\frac{1}{4}$ -in. screen, and as a consequence dust losses were high. An investigation resulted in correcting the trouble by enlarging the dust chamber, diverting converter gases from the main chamber through a separate flue and header to the stack, and finally, after experiments with the Dwight-Lloyd sinter-roasting process, adding six McDougall roasters and two reverberatories. Changes in ore supply necessitated the later construction of one more reverberatory and three roasters. Again, on account of an increase in sulphide ores, seven more roasters were added to partly roast the material for the blast furnace and give better control over the sulphur content, and consequently the grade of matte. The old barrel-type of converters were replaced with 12-ft. Great Falls vertical type, and acid lining gave way to basic. Where the old plant in 1904 could treat with difficulty 2000 tons per day, the present plant can easily handle from 4000 to 5000 tons and can be run in such a manner that metallurgy and costs can receive careful attention.

The method of fettling the reverberatory furnaces is different to that found in other plants. No barren silicious material is used, as with the basic slag made it is too expensive to keep the furnace properly fettled with this material, and it has a tendency to blanket the charge. At present the front half of the furnace is lined with magnesite brick and is not fettled; in the back half ore is used for protecting the lining, running as high as 35 per cent iron, as low as 25 per cent silica, with sulphur from 15 to 18 per cent, and copper about 5 per cent. It is essential that the ore contain enough sulphur to matte the copper, or it will be carried out in the slag in the form of prill.

Progress in Copper Metallurgy in the Globe District, Arizona, is briefly outlined in a paper by Mr. L. O. HOWARD of the Old Dominion Copper Mining Co. Prior to the present decade different small smelting plants had been operating in the district, and the Warrior Copper Co. had made an unsuccessful attempt to leach oxidized and silicate ores with sulphuric acid. The United Globe and Old Dominion smelters remained in operation, but they were poorly equipped and were operated intermittently on account of uncertain supplies of ore due to poor railroad facilities. With improved transportation facilities conditions improved; but it was not until Phelps Dodge & Co. obtained control of the Old Dominion that a betterment in metallurgical practice began. The furnace equipment has been increased until the plant has a capacity of 1500 tons of charge daily. No reverberatories have ever been built, and the fine concentrates are mixed with coarse ores, relying on adequate dust chambers to recover the flue dust. Improvement in converting practice began when the usual barren silica and clay lining was replaced by silicious copper ores with aluminium slime from the concentrator for a binding. Later, blast-furnace flue dust was added to the mixture to the extent of 25 per cent without materially shortening the life of a lining. Finally, the Great Falls type of basic-lined converter was adopted. With this installation, using only one shell at a time, it has been possible to produce more than three and one-quarter million pounds of copper per month from a 42 per cent matte. One converter has been in continuous use for over 18 months, producing more than 45,000,000 pounds of copper without expending one cent for repairs to the lining.

The existing concentrator was remodeled in 1912, its capacity being increased by 500 tons. Oil flotation is used for the recovery of the fine material.

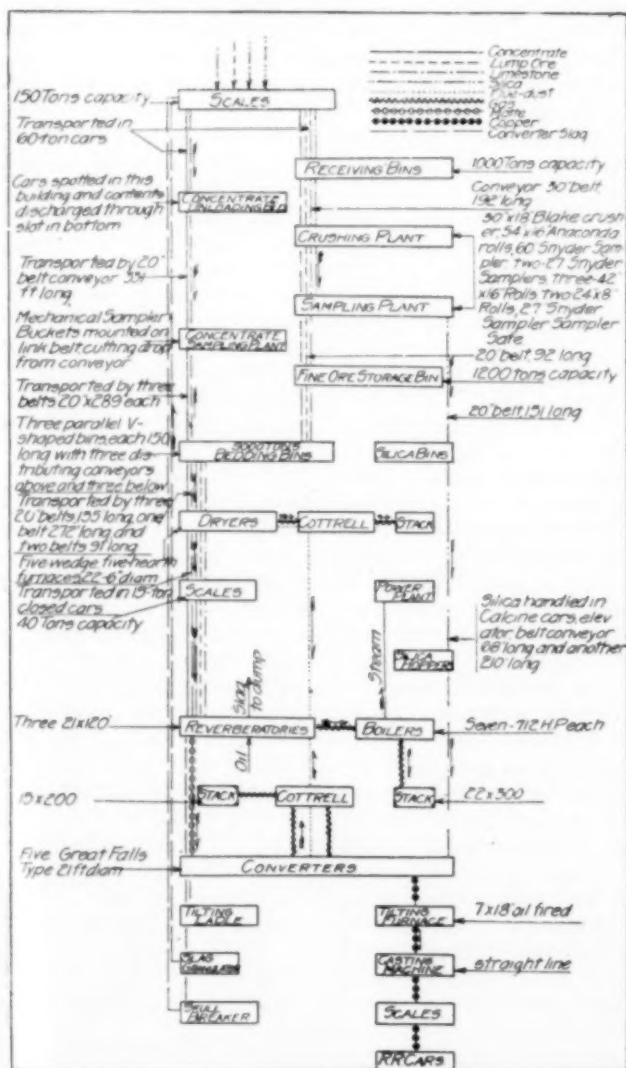


FIG. 1—FLOW SHEET OF NEW PLANT OF INTERNATIONAL SMELTING & REFINING COMPANY

tional S. & R. Co., a flow-sheet of which is shown in Fig. 1, will also have reverberatories for treating the concentrates from the Miami and Inspiration mines. These furnaces will be 21 ft. by 120 ft., and the concentrates to be smelted will contain approximately 40 per cent copper, so that their production will exceed that of any other Arizona smelter. In conclusion, Dr. Douglas gives an outline of the equipment at Arizona smelters.

The Copper Queen Consolidated Smelter was the subject of a paper by Mr. FOREST RUTHERFORD of Douglas, Arizona. The plant was started in 1904 with five

The Design of Modern Copper Plants is ably reviewed in a paper by CHARLES H. REPATH of Los Angeles, Cal., who has constructed some of the most modern copper smelters. The author speaks of the necessity of an organization of experts in order to secure the best results in design and construction of a copper smelter. The Washoe smelter of the Anaconda Copper Mining Co. is cited as the first of the great modern plants that was built by a corps of trained specialists. The design was based on experimental work in older plants; but as larger units were required new designs were made either by the company's engineers or by manufacturers, with the result that many innovations were made, such as large roasting and reverberatory furnaces, blast furnaces and converters. The segregation of the different departments was adopted because of the magnitude of the operation and to provide room for extension.

The author reviews the general principles in design and construction that are now followed in copper smelting plants. An accurate sampling and weighing plant is a necessity if metallurgical operations are to be conducted intelligently. The modern sampler delivers 1.6 lb. of ore to the sample bin for every ton that passes through the equipment. Automatic-recording belt-weighers record the weight to within 0.5 per cent. Belt conveyors are used for transportation of ore between different departments, displacing intermittent methods by means of cars. Bedding plants are used to secure proper mixture of ores for the furnaces. The weight and analysis of the bedded materials are known, and when the bed is partly completed calculations are made to determine its constituents and see what additions must be made to give the desired mixture. The beds are uniformly built by automatic trippers and reclaiming is done by Robins-Messiter machines, which remove the material simultaneously from all parts of a cross section of the bed and deliver it to conveyors.

In the design of roasting furnaces concrete hearths are proving satisfactory and are likely to displace the ordinary brick hearth. The furnaces are of the McDougall type, with superimposed hearths, large central shaft, and air-cooled rabblers and arms. In the Herreshoff furnaces installed at the Calumet & Arizona and the Arizona Copper Co., air is delivered to the furnaces under pressure, and is positively circulated through the vertical shaft and rabble arms.

For the recovery of flue dust, the author is of the opinion that combinations of the flue system, with baffle plates, partitions or wires, and the Cottrell electric precipitation system, may be adopted. Chimneys are built of reinforced concrete, common brick, special brick, and steel plate lined with brick or unlined, depending on conditions. The United Verde has a steel chimney with a 4-in. lining of brick, 30 ft. inside diameter and 400 ft. high. Smoke damage is a problem receiving a great deal of attention, and is being solved by building acid plants or by using high chimneys to diffuse the gases over as wide an area as possible.

Improvements in reverberatory construction have been in the length and width of the furnaces, the use of a larger brick and heavier roofs, the application of fettling material at the sides of the furnace, and the utilization of waste heat for steam generation. Fuel oil and pulverized coal have supplanted direct coal firing. Large furnaces 175 ft. long are being designed, using pulverized coal for firing, and charging the ore along the sides of the furnace. There will be a continuous flow of slag as in blast-furnace practice.

Blast furnaces have been increased both in length and width. They have been built up to 87 ft. long and 7 ft. wide, but the trend of furnace building indicates a length of about 40 ft. and a width of 4 ft. Such a

furnace will treat over 1000 tons of charge in 24 hours. Jackets are being made in one length instead of two. 17 ft. long and 3 ft. 4 in. wide. Furnaces are being built with air-cooled tops of structural and plate steel and no brick work. The use of hot blast has not proved satisfactory, although in theory it should be economical; but the first cost of the furnace is greater and the repairs may be more due to greater complication. Mechanical systems are used for delivering ores to the blast furnaces. Charges are usually made up at storage bins, weighed into scale hoppers and dumped into charge cars. The latter are then hauled to the furnaces by electric motors and dumped by air hoists.

"At the Calumet and Arizona plant the method of charging the furnace is new and unique. The ore and coke bins are located on the charging floor, and above it, so that the material will drop through openings in the bottom of the bins into the charge cars. These bins are filled by means of conveyors from the bedding system where the ores have been properly mixed ready for charging the furnaces.

"The gates in the bottom of these bins are air operated, and so are easily manipulated. The large charge cars stand on scales located in the floor, and the man who has the work in charge loads into them the ore or the coke, as may be required. These cars have four compartments, so that the amount placed into each compartment will be the amount required in the section of the furnace that it is supposed to serve. After the car has been loaded, it is moved forward and dumped into the furnace. The bottom of the car is on a 45 deg. slope, so that as soon as the doors are released by the operator, the charge drops into the furnace. There are four cars to each 40-ft. furnace and they are alternately loaded with ore and coke. The car is electrically propelled. There are four large doors to each furnace and they are operated by compressed air.

"Another unique feature in the construction of these furnaces is the method of supporting the side and end jackets. The side of the furnace is supported by a built-up plate girder which becomes the lower side of the bustle or main air-pipe, thus using a minimum of space for supporting the jackets and permitting their removal when necessary for repairs. From this heavy girder, and also from the girders at the top of the furnaces, screw jacks are provided, and they are connected to the top and center of the jackets, the screw adjustment permitting the securing of the jackets in a strong and substantial manner."

Slag disposal is accomplished by hauling to the dump in ladle cars holding from 20 to 25 tons. Under certain appropriate conditions the slag can be granulated in water and sluiced to a dump. The recovery of the heat in the slag has been the subject of much experiment, but little has been accomplished in a commercial way.

Large cylindrical and vertical converters with linings of magnesite brick are now generally used. Cylindrical converters are built up to 10 ft. in diameter and 25 to 30 ft. long. The vertical type is built as large as 20 ft. diameter. The method recently adopted for disposing of converter slag is to carry it by cranes to reverberatories into which it is dumped. The furnaces act as settlers which permit the matte to separate from the slag. Where converter slag is to be used in the blast furnace it is cast into a mold arranged on a machine such as a Walker casting machine. The breaking of ladle skulls is now done by the McGregor skull breaker in which a drop hammer on a traveling crane breaks the skulls into pieces small enough to pass a grizzly with 6-in. or 8-in. openings. Copper is handled in casting machines of two types, round and straight-line. While

more power is used about a modern smelter, it is produced cheaper than formerly. Costs have been greatly reduced in every department of a modern copper smelter.

The **Physical Properties of Copper** was the subject of a paper by Prof. CARLE R. HAYWARD of the Massachusetts Institute of Technology. The paper gives electric and thermal conductivities and an account of the effect of gaseous and metallic impurities. Accurate equilibrium diagrams are a great aid in choosing elements to produce a certain effect. The heat treatment of copper alloys is of greatest importance and needs systematic research.

Mr. Addicks discussed the effect of oxygen on copper and suggested the casting of ingots on end as in steel practice.

Electrolytic Copper Refining was the subject of two papers on this subject, covering the development and progress in the art of electrolytic refining.

The first, by Mr. A. C. CLARK of the Raritan Copper Co., Perth Amboy, N. J., states that commercial electrolytic refining of copper did not begin until 1860, when batteries were used as a source of current. The dynamo came into existence in 1866. The Welsh process of copper refining had been developed to a high state of

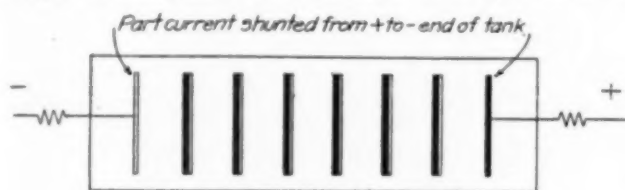


FIG. 2—SERIES SYSTEM

perfection, but failed to produce copper of high electrical conductivity. Gold and silver could not be parted from copper by this method, and in 1883 electrolytic copper refining began to be widely considered. Two refineries were established in 1887, and from that time the growth in electrolytic refining was enormous. The present output is about 1,500,000,000 lb. per annum.

Two systems of electrolytic refining are in use, the series and the multiple, each having advantages and disadvantages. The arrangement in the two systems is shown in Figs. 2 and 3.

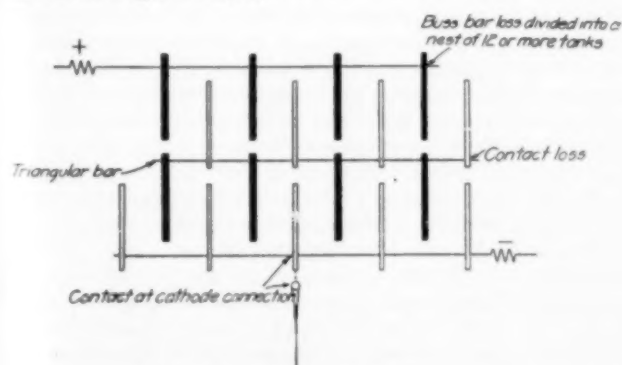


FIG. 3—WALKER MULTIPLE SYSTEM

The series system probably found favor in early days owing to lack of a suitable generator. Standard generators having a normal ampere output were satisfactory for use in this system, while it was necessary to use a number of generators connected in parallel to generate sufficient ampere current for the multiple system.

The multiple system has been greatly improved in recent years, and the former difficulties simplified by Walker's arrangement. Instead of using one tank subdivided into two cells, with heavy copper bus-bars on each side of tank and individual connecting contact

strips between the electrodes of each cell, Mr. Walker groups his cells in batteries of from 10 to 17, requiring only one heavy bus-bar for the first and last cells, and by using small triangular copper bars on the intervening partitions of cells, he effects a two-fold saving in voltage, due to a shorter electrical circuit and to a lower resistance due to the sharp contact between the anodes and cathode rods and the triangular bars. This system also largely decreases the cost of installation. The internal electric circuits—namely the rod supporting the cathode and the clips between the cathode and cathode rod, the copper resistance of the anode itself, and the three electrode contacts—still form a serious loss in the multiple system that is not in evidence at all in the series system. However, the potential of the multiple system is so extremely low that it is easy to obtain an ampere efficiency of 90 per cent, while with the series system the current leaking from the first positive to the last negative electrode in the tank effects a power loss which fully equals the loss by the voltage drop in the copper circuit and contact resistance of the multiple system.

The quality of electrolytic copper has greatly improved. Early production was irregular in quality, due to impurities, and sold at a discount from the price of Lake copper; and this unjust discrimination has continued to the present day. At present electrolytic copper is uniform in quality and far superior, by analysis, to Lake copper. The early irregularities in quality were due to engine or generator troubles, insufficient circulation of electrolyte, undue variations in temperature, irregular chemical composition of solutions, etc. At present, however, electrolytic cathodes are hard and smooth and assay 99.96 per cent copper. As showing the high degree of purity of electrolytic copper now produced, its conductivity is frequently 102 per cent and over, based on Matthiessen's standard on supposedly pure copper in 1865. Arsenic is the most deleterious substance in refined copper. If 0.01 per cent is present, the conductivity is reduced about 3 per cent. The maximum quantity of arsenic permissible in first-class electrolytic castings is 0.002 per cent in oxide form.

Electrolytic solutions are generally circulated by centrifugal pumps invented by F. L. Antisell, of Perth Amboy. The pump is made of hard lead, without packing glands or wearing parts being subjected to corrosion. Charging machines are used to charge the furnaces, which have capacities up to 500,000 lb. Furnaces are partly or wholly lined with magnesite or chrome brick instead of the old silica brick, thus effecting a saving in slag production and cost of repairs. Casting machines are generally used. In the Clark & Clark casting wheel used at the Raritan works, the copper is tapped from the furnace into a ladle and six bars poured simultaneously, the molds being set radially on the casting wheel.

In the paper by LAWRENCE ADDICKS, the author points out that the development of the dynamo provided a suitable source of current for electrolytic refining and at the same time made possible the development of many electrical industries and thereby created a demand for high conductivity copper which can be produced only electrolytically.

If we say that electrolytic refining costs $\frac{1}{2}$ c a pound over fire refining and that copper sells for 15c a pound, it will take but a 3 $\frac{1}{3}$ per cent gain in conductivity to pay for the refining, when electrical uses are involved. Further, it is quite impossible to make a clean separation of silver and gold from copper by fire methods, while the "values" in cathode copper run but a few cents a ton. Copper is nearly always associated with silver and gold and our $\frac{1}{2}$ c a pound increase in cost calls for but \$10 a ton of either or both of these metals to justify electrolysis from this standpoint.

The author divides the development of copper refining into three stages: That of early development; that of tonnage extension, and that of efficiency work. The first period ends with the introduction of mechanical ladling and the general use of cranes for handling electrodes; the second period covers about six years and witnessed the construction of the first really large plants; the third period covers the ten years just closed, with plenty of work in sight to put refining on a finished basis.

As a result of the construction of large furnaces, up to 600,000 lb. capacity, refining is done for less than half the cost in the best of the old hand-ladled furnaces.

Furnace charging is now done mechanically at the rate of 300,000 lb. an hour. Melting has been accelerated by forced and induced draft, and the modern furnace has waste-heat boilers. Hand-firing, combined with what is practically a gas-producer fire-box, holds its own as against mechanical stoking, oil firing or the use of pulverized coal. Coal consumption has decreased with the increase in size of furnaces, from about 20 per cent at 40,000 lb. to 10 per cent at 600,000 lb. Hand-rabbling has been displaced by blowing with compressed air. Skimming is done by rabbles, but the proportion of slag made has been reduced from 4 per cent to less than 1 per cent by keeping silica from the furnace lining, or from coal ashes, away from the cuprous oxide formed while melting and blowing. Crushed low-sulphur coke or anthracite coal is used to blanket the bath instead of charcoal. Poling is still done with green hard-wood poles. Laddling is done mechanically at as high a rate as 90,000 lb. an hour. Fettling is practically eliminated in basic-lined furnaces.

The only obstacle remaining to making furnace refining a continuous melting process, is sulphur brought over as sulphates from the tank-house or absorbed from the products of combustion.

The characteristics of the power requirements are high amperage, low voltage direct current, with a 100 per cent load factor. As individual circuits are limited to about 1500 kw., the reciprocating steam engine is at its best under these conditions, and up to date a high-economy, slow-speed, compound- or triple-expansion engine, generating a kilowatt-hour for about 15 lb. of steam at 150 lb. pressure sq. in., 100 deg. Fahr. super-heat, and 27-in. vacuum, has been favored.

In the tank-house the Walker system of connections mentioned above has been adopted. The size of anodes has been increased to 3 ft. square, and even to 4 ft. in one leaching plant. The number of anodes in a tank also has been increased from 26 to 32. Current densities have risen to nearly 20 amperes per sq. ft. A current efficiency of about 90 per cent seems to express the economical balance between labor and power. Lead-lined wooden tanks are still used, but much experimenting is under way with various types of tank construction. With anode copper of 99 per cent or over, an electrolyte with 2.5 to 3.0 per cent copper and 12 per cent free sulphuric acid will give good results with almost any quantity of arsenic, nickel, etc. The electrolyte is generally purified by daily diverting the necessary portion and removing copper and arsenic as a cathode sludge, using insoluble anodes. The resulting liquor is concentrated by steam in lead-lined tanks and direct heat in iron vessels to a heavy liquor consisting of strong sulphuric acid and sodium sulphate, the sulphates of iron, nickel, etc., having fallen out as anhydrous salts. The sodium sulphate can be removed by chilling, and the sulphuric acid returned to the electrolyte. The addition of a small quantity of hydrochloric acid or salt causes antimony to slime as oxychloride. Glue or similar organic addition agents in small quantities aid in forming smooth cathodes.

The refining of anode slime is still in a transitional stage. Wet processes are being experimented with on account of metal losses in fire processes. A simple fusion of raw slime will give bullion, matte and slag. The bullion will contain lead, copper and the precious metals; the matte, copper, silver, selenium and tellurium; the slag, arsenic, antimony and the more easily oxidized metals. If the slime is roasted to oxidize copper, and that metal then dissolved as sulphate in suitable tanks, the remaining slime will form little matte when fused. After fusion in a small basic reverberatory the bath is skimmed clean and the base bullion refined to a high grade, done by blowing and nitreing. The slag is sorted, part sent back to the anode furnaces, part desilverized by a quiet fusion to free it from prills and part charged back into the silver furnace. The silver and gold are generally parted electrolytically and the resulting gold slimes treated for recovery of platinum and palladium. Selenium is recovered from the silver refinery flue dusts by leaching and reduction with sulphur dioxide.

One of the great difficulties in the way of devising a comprehensive wet process lies in the great variation in composition of the slimes at different times and places and in the number of elements present. The strong solvent action of ferric sulphate upon copper and the purity of silver chloride precipitated from foul solutions give a foundation for a wet process. The progress in electrostatic fume recovery is helping out the older process.

Leaching of Copper Ores was the subject of a paper by Mr. W. L. AUSTIN, Riverside, Cal. This is an elaborate compilation, correlating important data collected from the recent extended experiments of different companies. The process is applicable under different conditions as at Chuquicamata, Anaconda and Calumet & Hecla. Sulphuric acid is the choice of lixiviants. As to precipitation, local conditions determine the choice between scrap iron or chemical or electrolytic precipitation.

Friday Sessions

The two last sessions of the Section on Metallurgy were held on the morning and afternoon of Friday, Sept. 24. The morning session in which Mr. Chas. Butters presided was devoted to the symposium on gold and silver, arranged and edited by Mr. C. W. Merrill. The papers by G. O. Bradley on a coarse crushing plant of 1000 tons capacity, L. D. Mills, and M. H. Kuryla on crushing and grinding, M. H. Kuryla on solution of gold and silver, L. D. Mills on filtration or separation of metal-bearing solution from slime residue, and G. H. Clevenger on precipitation were read and discussed.

The afternoon session in which Mr. E. B. Braden presided was devoted to the papers on zinc (symposium arranged by Mr. W. R. Ingalls), lead, and fuels.

Limitations of space force us to reserve accounts of all Friday papers and discussions for our next issue.

All the social functions of the Congress and the excursions were carried out according to the program. The whole congress was a great success.

Canada Mineral Production.—The value of the mineral production in all Canada in 1914, according to revised statistics, was \$128,556,268, as compared with a total output valued at \$145,634,812 in 1913. In the Province of Alberta the 1914 production was \$12,684,234 as compared with \$15,054,046 in 1913. Coal is the leading product in this province with about ten and a half millions in 1913 and nine and one-third millions in 1914. No gold is recorded as having been produced in 1913 and only to the value of \$992 in 1914.

The Aniline Dye Situation*

BY I. F. STONE

In rising to speak of the aniline dye condition in the United States at this time, it is perhaps needless to repeat what is already known to those who are interested in aniline colors either as merchants or consumers, and in fact, known to many of the public through the newspapers; that there is a very great shortage in supplies owing to the fact that goods, which formerly came from Europe upon which we depended largely for our supplies, are by reason of the war no longer sent over; therefore, American consumers are not able to get anything like the supply to which they have been accustomed and upon which they depended.

Eighty per cent of the colors consumed in the United States were brought over from Europe, principally from Germany, so that upon the stoppage of the imports from Europe, 80 per cent of the supply would naturally disappear. The other 20 per cent had been furnished largely by American manufacturers, but even this 20 per cent of the supply has not been maintained by the American manufacturers because they have been depending upon Europe for a large part of their intermediate or raw products, and when they were no longer able to get these products from Europe, naturally they could only run their factories as long as their stock on hand would enable them to do so. Their only chance, then, to continue running their factories was to make these raw or intermediate products themselves, and while this has been done to some extent, as I will explain later, it has not yet reached a stage where they can get full supplies of every raw material they need to produce the full line of colors which they have been manufacturing. Consequently they are unable to furnish some of the colors which they formerly supplied.

This leaves the consumer in a very critical position, as if he wishes to run his factory he must do so without his usual colors, meaning that he would have to make a different class of goods as far as colors are concerned, or else only operate part time, or close down altogether for lack of these dyes. Most of the factories have adopted the part-time method, in that they are manufacturing such goods as require little or no dye-stuff, or else manufacturing such goods for which they can secure colors in America to manufacture. In some lines, for instance the hosiery and possibly the leather manufactures, this can be done to quite a large extent, as they use mostly blacks and other dark colors which are manufactured comparatively largely here; that is, for hosiery, direct and sulphur blacks, and for leather, blacks, nigrosines and logwoods, which can be obtained here almost in the necessary quantities. Other lines of manufacture, however, requiring fancy shades—such as silk manufacture, or manufacture of goods requiring indigo, alizarines, and other fast colors, paint and printing ink manufacturers, requiring special colors for their lakes to make their paints and printing inks, paper manufacturers requiring large quantities of blue to manufacture white paper and fancy shades, and many other industries not mentioned—are unable to obtain anything like their requirements and are accordingly not doing their usual volume of business, and many employees are therefore working only part time at a consequent great loss to themselves and to their employers.

The reason for this acute situation is manifestly, of course, the present European war, but, as a matter of fact, it could have been avoided largely by what I might call better judgment of two nations, viz., Germany and

the United States. In explaining the situation I shall perhaps have to say something which will reflect upon the business methods of one nation—the German—and the political methods of the other nation—the United States. But whatever I do say will be without animosity, and simply a plain statement of facts, and should be taken as such.

The Attitude of the German Color Manufacturers

At the beginning of the war it was, of course, impossible for the German factories to ship their usual quantities over here because of the fact that the German Government had taken charge of all the railroads and other means of transportation for moving their troops and war supplies, and the German factories could not therefore get their colors to seaport for shipment; but after a couple of months this condition changed so that they were able to get their goods to the seaport, and did commence to make quite good size shipments to the United States, owing to the fact that they were able to do so on neutral or American vessels, and there was then no interference with these shipments on the part of England. The first large shipment, for instance, was made on the SS. Matanzas, which was chartered by American firms and sent over specially for the bringing over of dyestuffs, and this vessel subsequently made several other trips.

After this followed many other chartered vessels, and comparatively regular shipments were made until the spring of this year, when they ceased completely, for the reason, I believe, partly of the action of England in taking measures to prevent such shipments, and partly because the Germans were disinclined to make shipment when they could not get anything in return from this country, cotton and foodstuffs for instance. Had, however, the German firms taken advantage of the time when they could make shipments and had sent to this country a large supply of their products, their agents here could have accumulated large stocks which would have carried them over a long time and so largely prevented the acute shortage of the present time. But for reasons best known to themselves, they decided to ship to this country each month only about 75 per cent of their regular normal shipments, consequently a shortage of at least 25 per cent, and perhaps more, continued in spite of the German shipments. When I say that the German factories could have made large shipments, I say this for the reason that normally only about 20 per cent of their production was shipped to the United States, while the other 80 per cent was used in their own country and shipped to other parts of the world, and as at the time of the war they were barred from shipping to other parts of the world, a large percentage of this 80 per cent was available for shipment to the United States, and they could therefore have shipped to us many times the quantity they did ship, and if they had done so their American agents might have acquired a stock which would take care of their customers for perhaps a couple of years or more on some, if not all, of the colors. I say, therefore, that the German firms are responsible for the difficulty and the acute position of the American consumers. Their primary reason for this holding back of shipments was probably due to the fact that they did not want American consumers to get an oversupply of colors so that they could make up extra quantities of goods which they might use for export to customers in other countries who had formerly bought the same goods from Germany, but who could no longer obtain them. Therefore, they restricted as far as they could the American supply so that they would only have enough goods to supply what might be called their normal trade and could not increase their production.

*An address delivered before the National Exposition of Chemical Industries, New Grand Central Palace, New York City, Sept. 22, 1915.

On the intermediate or raw products which they had formerly shipped to American color factories an embargo was immediately placed by the German Government, so that they could no longer be shipped, the embargo being apparently for the reason that many of these materials were for the use of manufacturing explosives which were required by the German Government in their war movements; but as a matter of fact many of them, like aniline oil, beta naphthol, paranitraniline, naphthalene, and such articles, were not so necessary for this purpose, and large quantities of these could easily have been shipped over here and used in the manufacture of colors by American factories, and also in many cases by consumers themselves, as, for instance, aniline oil for blacks, and paranitranilin and beta naphthol for manufacture of colors by paint manufacturers.

The movement of German colors and intermediate products and chemicals was really controlled by a committee called "Verein zur Wahrung der Interessen der Deutschen Chemischen Industrie," the chairman of which, I understand, was a director of one of the large German color factories, and the reason then that larger quantities of various products were not sent when they could have been sent was evidently due to the judgment of this committee in reducing and finally stopping, because they considered it to the best interests of their manufactures to do so, for reasons already partially explained, and they therefore are really responsible for the present acute condition of the aniline dye supply in this country.

Whether or not it was really to their advantage to take this position it certainly was not to the advantage of American consumers, therefore in the future it seems to me they should bear in mind the position taken by German manufacturers in that the American consumers' position was not considered, and in the future ally themselves as far as they can with American manufacturers who are developing or about to develop the manufacture of aniline dyes in America to as large extent as may be possible, or to a comparatively small extent if the American Government does not come to their support by fixing a new and higher tariff on these goods so that American manufacturers can compete with Europe under normal conditions, but to a large extent if such protection is given.

The Situation of the American Manufacturer and the Necessity of a Tariff

This is really the crux of the whole situation as far as American manufacturers are concerned, viz., whether or not they will be given proper protection, and if so, as I have said, the business will develop to a large extent and in the course of time be practically independent of foreign supplies. I made this same statement in a circular which our company issued on Sept. 1, 1914, just a month after the war started, that is, that the American manufacturers could not make much progress without such protection, which I again repeated in an address before the American Chemical Society of New York on Oct. 9, 1914. As a result of this address, a committee was appointed by the American Chemical Society to look into the matter, and this committee subsequently reported on Nov. 6, 1914, that such protection was necessary, and advocated that the present duty of 3 per cent ad valorem be continued with an additional duty of 7½ cents per pound specific on finished colors, and an ad valorem duty of 15 per cent and 3¾ cents per pound specific on the intermediate or what might be called half-finished products.

This necessity was so apparent that it was even signed by one of the committee, Mr. H. A. Metz, who is

the American representative of a large German color factory, whose personal interests naturally lie in the importation of colors, and who would not have signed it had it not been absolutely a necessary action if the development of the color business were to be largely increased in the United States.

This resolution, or report, was duly sent to the proper authorities in Washington, and has been on file there since that time. It is a reflection, I think, on the American Government that no action whatever has been taken in this matter, but here comes a question of politics, the present administration having been elected on the platform advocating reduced tariffs, and therefore will not apparently go back on their platform, even under the present unusual and unexpected conditions, even though American consumers are suffering for relief, in that many thousand employees of manufacturers requiring colors are reduced to only part time and, in fact, some of them laid off entirely by reason of their employers not being able to secure the necessary amount of dyestuffs to continue their regular productions.

In other words, the position of American consumers at present is not a political one, but one of cold fact, and should in my opinion have the attention of the administration irrespective of previous policies. Except that they have had practical example of the workings of a low tariff on aniline colors and coal tar products, and its flat failure as connected with this line of business, the result of which is the present deplorable condition, the present administration is no different from previous administrations for the last twenty-five or thirty years, both Republican and Democratic, none of them having given this necessary protection, and as a result not allowing the business to develop as it would have developed had they done so.

It is perhaps some excuse that they did not realize how large a part in the success of the manufactures of textiles, leather, paints, and many other lines, depended on their supply of dyestuffs, in that the business itself was perhaps not large enough to demand their careful attention, and they did not take into consideration the fact that so many other great lines depended on their supply of these goods. This fact was also not realized by many of the American consumers themselves, as is evidenced by the fact that during the many years that the tariff matters were before successive administrations many American consumers of dyestuffs fought an increase of duty thinking that it might increase their costs and evidently preferring to buy foreign goods at what they considered lower prices than to support the manufacture in America at a possible increase in cost to themselves by reason of a higher protection.

The fallacy of this position is now absolutely apparent in that the consumers are now not only not able to get sufficient supplies for their wants, but on what they do get are forced to pay fabulous prices, and certainly the extra cost of their supplies and their losses through failure to run their factories regularly will far exceed a slight possible advance in the cost of dyestuffs by reason of their being made in America under a protective tariff.

As an instance of prices which they are forced to pay when they do get goods I might mention a few products:

Sulphur black, which is used very largely by the hosiery and cotton trades, and which sells normally at about 20 cents per pound, has brought as high as \$2.75 and even \$3 per pound.

Indigo, which sold formerly at about 15 cents, has been sold as high as \$1 per pound, even more.

Aniline oil, the normal price of which is about 10 cents, as high as \$1.75 per pound.

Beta naphthol, with a normal price about 12 cents, sells as high as \$1.50.

Paranitraniline, normally about 15 cents, sells as high as \$1.75.

I might continue this list indefinitely, showing where all products for which consumers depended on European supply, that is, which were not manufactured here, are now selling at anywhere from five to twenty times their normal value.

I might call attention in this connection to the fact that these enormous advances do not apply on colors and products which were made regularly in America; for instance, such products as direct black, Bismarck brown, chrysoidine, nigrosine and any number of other colors, have not been advanced by American manufacturers more than two or three times their normal selling price, and this advance was only caused by reason of the fact that their raw materials are also used in the manufacture of ammunition and explosives and are now in large demand for this purpose, so large a demand, in fact, that American manufacturers of colors have been unable to get adequate supplies, and so for what they do get pay abnormal prices; benzol, for instance, having advanced from a normal price of about 20 cents to as high as \$1.25 for immediate shipment, and on contract to about 65 cents at the present time, while toluol, with a normal price of about 25 cents, has been sold as high as \$6 for immediate supply and on contract at this time about \$4.25. Had these advances not taken place by reason of their demand for other purposes the manufacture of American colors could have continued on almost normal lines, so they are not to blame for the necessity for advancing prices to the extent they have, which, however, is no comparison to the advance in the prices of European colors which have not been made here.

I might say that the one American manufacturer of aniline oil before the war, even in the face of these enormous advances, continued to fill contracts at the old contract prices, and when they arranged to increase their production to a large extent only advanced the price in proportion to the advance in raw materials, and had it only been able to manufacture enough aniline oil to supply the country, which it was not at the time, the price on this article would not have soared to \$1.75 as it has, but would have been held to some reasonable figures. This shows the policy of real American manufacturers, which is to protect their customers as far as possible under unusual conditions, and has also been the policy of color manufacturers.

The matter of tariff being so important a factor in the development of the color business in the United States, I might call your attention to an article recently written by Dr. B. C. Hesse, a well-known aniline expert, and published in pamphlet form, headed, "Who Killed Cock Robin?" and which gives the United States tariff history for the past thirty years. He calls attention to the fact that there was from 1880 to 1883 a duty of 35 per cent ad valorem and 50 cents per pound specific on aniline colors, which gave ample protection to the industry, and as a consequence there were then nine or ten factories in the United States, and the prospect of becoming independent of other nations for our supply of these aniline products was bright indeed. But the passage of the tariff act of July 1, 1883, which abolished the specific duty of 50 cents per pound, leaving only the ad valorem duty of 35 cents, and fixing a 20-cent duty on the intermediate products, which left only a net protection of 15 per cent, immediately checked the industry here. No new factories were started, and within one year after the new tariff took effect five of those already established were forced to succumb and

go out of business, leaving only four to continue the work, who have since stayed in business but have not been able to develop to any extent. I might say that a specific duty of 50 cents at that time was not exorbitant, as the prices of aniline colors then manufactured were very much more than they are to-day, colors, for instance, selling at \$4 to \$5 per pound now sell at only 50 to 60 cents per pound, so that the 7½ cents specific duty now recommended by the American Chemical Society would not be very far out of proportion to the 50 cents per pound at that time.

Had a proper duty been kept on these aniline products, say from 1883 to about 1900, during what might be called the golden progress of the industry, when so many new colors and products were brought out, the business might be here to-day in the same prosperous condition as it has been in Germany, where, as everybody knows, enormous factories have been erected and the business of the world practically controlled by them. It is, of course, due to the Germans to say that many of their new products were patented colors produced through the careful research work of their chemists, but no one can say that American chemists would not have been equally diligent in research work had they had the same opportunities. Moreover, had the United States at that time had a proper patent law which would compel the manufacture in this country of all goods patented by foreign residents, it would have protected the industry and insured its great success. Our legislators, however, did not appreciate the importance of the business, and so failed to give us the proper protection and proper patent laws, and therefore the business has drifted away from the United States and resulted to the great credit and prosperity of the German manufacturers.

However, these patents have now practically expired, and the American manufacturers are free to manufacture practically everything that is needed, so I must emphasize again that it is now only an insufficient tariff which prevents the development of the American industry in the future. This pamphlet of Dr. Hesse's also shows that in the various tariff negotiations in Washington during the various administrations, fights against an increased tariff were made not only by foreign manufacturers and their representatives, but were actually supported by American manufacturers and consumers whose names are given and who are now, I think, very sorry that they took this position and did not rather favor a protection and development of the American industry.

The American Consumer

To show you the lines of manufactures which are dependent on their supply of dyestuffs to continue their regular production, I would say the most important, perhaps, are the textile manufacturers, comprising cotton, wool, carpets, knit goods, silk, cordage, shoddy, dyeing and finishing. The following figures are taken from the census of 1909:

	Establishments	Employees	Capital	Salaries and Wages	Value of Product
Cotton ...	1,324	387,771	\$822,237,529	\$147,270,903	\$628,391,813
Wool	985	175,176	430,578,574	82,523,776	435,978,558
Carpets ..	139	34,706	75,627,010	17,745,092	71,188,152
Knit goods	1,374	136,130	163,641,171	52,431,680	200,143,527
Silk	852	105,238	152,158,092	46,097,364	196,911,667
Cordage ..	164	27,214	76,020,366	10,995,545	61,019,986
Shoddy ...	88	2,320	6,886,825	1,196,376	7,446,364
Dyeing and finishing	426	47,303	114,092,654	26,261,634	83,556,432
	5,852	915,858	\$1,841,242,131	\$384,522,370	\$1,684,636,499

You will see that there are over 5000 of these establishments with over 900,000 employees, with a capital invested of \$1,841,242,151, who are paying in wages annually \$384,522,370 and the value of whose product is \$1,684,636,499.

Then there are the leather manufacturers and tanners, of which there are over 900 establishments, with a capital of \$322,726,952, employing over 62,000 people and the value of whose production is \$327,874,187.

Then again there are the paper manufacturers, numbering over 750, with over 81,000 employees, with capital invested of over \$400,000,000 and the value of whose product is over \$260,000,000.

Then there are the paint and color manufacturers, about 900 in number, with a combined capital of about \$250,000,000 and employing 30,000 men.

As I said at first, these figures are taken from the census of 1909, and those who are interested in these particular lines tell me that there has been an increase in practically every industry averaging about 25 per cent, so that the figures should be something like 20 per cent more than those given. Add to these lines of business others which are not separated in the census, such as printing and writing ink manufacturers, shoe dressing manufacturers, and a hundred and one other lines which consume dyestuffs, and I think I could safely say there are upward of 2,000,000 people employed in industries which require the use of dyestuffs and who are now affected by the present shortage. Others affected, of course not so directly, are the public generally, who will soon find that they cannot get what they want, and will have to take what they can get, and if some changes do not take place very shortly a totally new scheme in colors will have to be presented to the American public.

The Attitude of the Administration

We have now come to a point where we are under unusual conditions, and the American industry again has a chance to develop, and it would seem a pity if the present administration would not take the opportunity to help manufacturers to do so.

The New York *Sun*, in its edition of Sept. 3, had a good article on the subject, and an editorial calling the attention of the President to the fact that while he might be engrossed in very serious affairs, such as the Mexican situation and the foreign wars, at the same time the new conditions and new complications arising from the present conditions should warrant his attention to see what prompt action and judicious protective legislation in the matter of the dyestuff industry might do for the country, saying further that the dyestuff industry is a single illustration only of the great trade advantages which the situation promises. This article and editorial were repeated and supported by many other American newspapers, and certainly represent a step toward accomplishing a revision of the tariff on aniline products to take advantage of present conditions.

I might at this time call attention to a popular belief which I consider a mistake, that an advance in the tariff on aniline products would necessarily result in advance of prices, but this is open to question, as while it is true that many of the cheaper colors might be advanced to some extent, on the other hand, the higher-priced colors, which have not been made in America and which are controlled by European conventions, would probably be actually reduced in price, so that the general average price on everything would not be possibly much different from what it is to-day under normal conditions. Then, again, there is the question of the so-called "anti-dumping clause," referring to the fact that it has been the habit of European manufacturers to sell in this country colors which were made here at lower prices than they sold them in other countries, so as to prevent their development here, while at the same time they held prices at good figures on colors which are not made here and so averaged up their profits. I am glad to

say that some legislation against these proceedings is favorably considered by the present administration, and no doubt some law will be passed which will prohibit this so-called dumping in the future.

In view of the emphasis I have placed on the necessity of tariff legislation, it may interest you to know what I have discovered in my interviews with various administration officials to get their ideas on the subject.

Some months ago, Secretary Lane of the Interior Department called a meeting of the various chemical manufacturers to get their ideas as to the situation and what was to be done about it, and at that meeting what little I said was to the same effect as what I am now saying, viz., the necessity of tariff action. Mr. Lane made the observation that if this were done it would create in this country a great monopoly or trust, and he did not think it would be advisable; but as a matter of fact the lack of this legislation has simply resulted in a great trust or monopoly in Germany, so I could not see where there could be any reason in this point. Such legislation would not necessarily create a monopoly here, as any one would be open to go into the business; the only point being that it would put us on equal terms with foreign competition, and this is the only result desired—not monopoly.

Mr. Lane further said, however, that the matter would probably be put in the hands of the Department of Commerce, which eventually did take place. Some time afterward I called on Secretary Redfield of the Department of Commerce and found that he was very sanguine of the ability of American manufacturers, through their ingenuity and ability, to create this business without help of a tariff, and instanced a number of new concerns who had started in the business since the war commenced, giving me the names of parties in Elizabeth, N. J.; Chester, Conn.; Edison of West Orange, N. J.; Wappingers Fall, N. Y.; Newark, N. J.; Stamford, Conn.; Perth Amboy, N. J., and Lincoln, N. J., who were about to enter the business, but as I knew most of these parties through previous inquiry I told him they were not being established for the manufacture of colors, but simply for such intermediate products as aniline oil, carbolic acid, beta naphthol and paranitraniline, which are more easily manufactured, and while they might be profitable under war conditions, could not possibly exist under normal conditions, which I believe is true.

Mr. Redfield was very much interested in the matter, and said that his department was doing everything possible to foster the development of the business in the United States, but could not say that he was in favor of higher tariff, as it was against his policy and against the policy of the present administration, but that he was in favor of some anti-dumping legislation which would prevent the selling in this country of European colors at lower prices than to other countries, and he thought something would be done in this line to prevent it in the future.

Notwithstanding the fact, however, that the administration as represented by Secretaries Lane and Redfield is apparently opposed to higher tariff, it is a fact that in the meantime Dr. Thomas H. Norton, special representative of the Department of Commerce, gave his views on a dyestuff tariff in the New York *Sun* and the New York *Herald* of Sept. 15. He admitted that in spite of the fact that he does not think the general line of colors need any more protection he does feel that some of them, like indigo, alizarine and others, which are on the free list should have some protection to be successfully made here, and if he were to go a little more carefully into the matter he would find that while 30 per cent duty on the ordinary aniline colors might

be sufficient if it were a clear protection, as a matter of fact the intermediate and raw products which are used in this manufacture carry a duty of 10 to 15 per cent, so that the real protection on aniline colors is not half what it apparently is in the bill. If it were possible to buy these raw materials made in the United States at approximately the same prices at which they can be bought in Germany, then the 30 per cent tariff would be more or less effective, but for reasons just mentioned, i.e., the duty on the intermediate products, it is not, and to show that this is a positive fact, without any theories, I would again call attention to the fact that since 1885 there have been practically no new color factories started in the United States, and the great business developed since that time all over the world has been practically controlled by Germany. If these colors had been properly protected, as I have already said, then a large part at least of this great business would have stayed in the United States, and now that we have again a chance to get to a quick development through the present abnormal conditions, certainly we should not throw away another chance to become a great factor in the industry and no longer be dependent upon foreign countries for our supplies.

Manufacturing Costs in Germany and in the United States

In the tariff pamphlet by Dr. Hesse already mentioned, there is a copy of a brief filed with the Congressional Committee who were working on a new tariff in 1908. This brief is dated Nov. 9, 1908, and is a complete statement of the cost and operation of an aniline color plant designated to manufacture 3,000,000 lb. annually. It was written and filed by Mr. J. F. Schoellkopf of the Schoellkopf, Hartford & Hanna Company, now called Schoellkopf Aniline & Chemical Works, and is confirmed and also signed by the Heller & Merz Company, one of the largest and oldest color manufacturers in the United States.

In Table A of this brief it is shown in detail that the cost of such a plant would be \$104,000 in the United States and \$70,000 in Germany, a difference of \$34,000 in favor of Germany.

In Table B the number of employees needed to operate such a plant is given in detail, and shows that their wages would amount to \$116,236 in the United States against \$61,493 in Germany, again a difference in favor of Germany of \$55,000.

In Table C a list of the cost of the material required for running this factory to a 3,000,000-lb. capacity is given, showing that the cost in the United States would be \$443,000 for these materials, which are given in detail, while in Germany the same materials would cost only \$317,000, a difference of \$126,000 in favor of Germany.

In Table D is given the cost of producing the colors as a whole, adding together materials, fuel, labor, interest on investment, depreciation of plant, etc., the table amounting to \$693,000 in the United States where it would only cost in Germany \$480,000, a difference of \$212,000 in favor of Germany.

The net result as shown by these figures is that it actually costs 44 per cent less in Germany to make colors than it does in the United States, and while, of course, these figures are now somewhat old, I think the same difference would still be true at the present time.

Take, however, the possibility that the present manufacturers are not correct in their statements as to this increase of duty being necessary, let us take the opinion of two possible new manufacturers; for instance, Mr. Thomas A. Edison, who when the war started found

that he could no longer get the large amount of carbolic acid which he consumed, and which was formerly furnished from Europe, promptly started to manufacture it himself, first making an arrangement with a large steel works for the benzol to make it from. In making the carbolic acid he also decided to produce aniline oil, and has been a producer of these products for some time. It was rumored at that time that he also intended to take up the manufacture of aniline colors, and this same rumor has been repeated in the public press in the last few days. Now, in an interview with him, published in a recent edition of the *Journal of Commerce*, he is quoted as saying that we can only become independent of Germany in the dyestuff industry if Congress will allow a moderate tariff, confirming the opinion of older manufacturers, and showing that after looking into the matter he was convinced that colors or coal tar products could not be manufactured successfully here in competition with Europe unless they had the proper protection.

Then the Pearsite Company of Cannel, Ky., who had lately been extolled by Dr. Norton as having a marvelous new process for manufacturing aniline colors by which they could manufacture them cheaper than the Germans and would soon control the entire consumption of the United States, gave an interview in the *New York Times* of Sept. 9, by Col. H. P. Bope, who is its president and also vice-president of the Carnegie Steel Company. Mr. Bope states in answer to a question as to whether his company could continue to compete with Europeans under normal conditions that he believed that the men in charge of affairs at Washington would readily see the necessity for and would give them the protection in tariffs that comes to all American industries. So you will see that Col. Bope's mind was also running on the line of protection in spite of the fact that the supposed new method of manufacture would entirely alter the whole situation.

The Attitude of the Administration Toward the Present American Manufacturers

Now, to come back to what the Government, through the Department of Commerce, are trying to do to help the production of dyestuffs in the United States, aside from any question of tariff, we find that while they are working diligently to do what they can they are starting from an entirely wrong point of view in that instead of trying to help the present manufacturers in the way of, for instance, securing them very much needed raw material and other helps to their production, they seem to be paying more attention to possible new productions, and to the claims of people who think they have wonderful new methods for producing dyestuffs which will render us independent of Europe for all time.

The first reports sent out by the department were to the effect that many new concerns were entering the field, which I have already mentioned in the account of my interview with Mr. Redfield, but it turned out that these concerns were not intending to make aniline colors, but only intermediate products.

Then the next reports of any interest were to the effect that they were working on agreement with the Swiss manufacturers whereby we were to send over to their country raw materials and the Swiss manufacturers were to make them up into colors and return them to us. That this arrangement has failed of any result is very natural, because the United States did not have the raw material to send—in fact, its own manufacturers could not get enough for their own wants—and if there had been any raw materials available it would have been much better for us to have given them to American factories instead of sending them to Switzer-

land. My own firm has recently had correspondence with Swiss manufacturers relative to furnishing them such articles as benzol, aniline oil, acetate of lime and oleum (which is a concentrated sulphuric acid). They stated they were unable to obtain supplies abroad, and we were obliged to write them that we could not get supplies ourselves, therefore could not send them anything from here. Aniline oil and oleum are out of the question, owing to the immense demand for them from American consumers, and benzol is practically barred because of its extremely high price and the enormous transportation charges for carrying it to Switzerland, which brought the total up to more than they are willing to pay.

The next what we might call important or interesting news given out by the Department of Commerce was an announcement in the *New York Times* of Sept. 4, in which it was stated in an interview with Dr. Norton, that an American had solved our dye problem, in that he had invented a new process for manufacturing colors which was much cheaper than the old process, and which would allow his factory to revolutionize the business in the way of costs and production, and that production would begin within two weeks, with a possible production of 5 tons per day, or 35,000,000 lb. per year—the total consumption of the United States, by the way, being about 30,000,000. The name of the concern which was to make these new colors was not given, but the next day, in the *Times* edition of Sept. 5, it was stated that the firm which would manufacture colors by the new process was the Pearsite company, which had large works at Cannel, Ky., and again repeated, with Dr. Norton's approval, that it would be ready to produce dyes in a few weeks, again mentioning 5 tons daily as its probable production, and further interviews with Dr. Norton on the subject were continued for several days, all to the effect that these new colors would be in the market in a few weeks in the quantities mentioned and would revolutionize the dyestuff conditions of the United States and relieve consumers from the present shortage.

I immediately received letters from all parts of the United States asking if we knew anything about the process and if it were true that colors could be had from this new company in so short a time, to which I replied that I did not know anything about it, except the newspaper reports, but that I doubted if it were possible for such a marvelous change to take place so quickly. Later, however, I have been in communication with parties who have actually had dyed samples and tried out the new colors, but instead of having an unlimited line of complicated colors such as are required by the United States consumers, some 900 in all, and which would be needed, a good many of them, to relieve the present shortage, the new company really only had five colors to begin with. This was also confirmed by an article in the *New York Times* of Sept. 15, stating that this would be the number of colors to be produced and giving the names of the new selling agents for these colors. The point to this matter is simply that instead of a marvelous new discovery which would alter the present conditions and relieve the present shortage of colors, as announced by the Department of Commerce through Dr. Norton, we simply have an experimental proposition which will not relieve the situation to any particular extent.

I do not question but that this Pearsite company may have some method of making colors which will produce colors, but I do say that it is impossible for them to have a method which would enable them to make all of the complicated colors consumed in this country and which are made not only from their base—benzol—but

many other raw materials which are combined with coal tar products, but which are not related to them at all, and which they could not possibly manufacture from a coal tar process alone. I do not believe that the Department of Commerce should allow such exaggerated statements to appear in the public press through their intervention, as it simply results in great disappointment to American consumers, who were hopeful that something had been found at last to supply their wants.

Mr. Redfield now says in an article in the *New York Sun* of Sept. 16 that "home dyes will be plenty soon," which if one did not know the conditions would again build up the hopes of consumers, while unfortunately there is no immediate relief in sight, and it must be months before a full quantity of dyestuffs can be obtained, even after the war is over. American consumers must understand this and take it into their calculations in figuring on their future production, and such statements should not be sent out by the Department of Commerce.

What American Manufacturers Have Already Done

Up to the present time I have mentioned the cause of the present shortage, the reason for and hope for a development in the manufacture of colors in America through tariff corrections on the part of the Government, and the attempt on the part of the Department of Commerce to create a new supply through other than ordinary methods, which, however, up to date has failed to produce anything of importance. I will now tell you what actually has been accomplished by American manufacturers to increase the production of American products in the United States, and those who have aided in this development are firms who will continue in business after the war is over, no matter what the conditions may be, even though they may have to do so at little or no profit unless they have some help from the Government. I am glad to say, however, that the development of the coal tar product business in this country will continue to a large extent, irrespective of what the tariff decision may be, but the development will not be anything as large as it would be if the tariff were corrected.

Aniline Colors.—There were five factories actually engaged in the manufacture of these products before the war, the names and locations being as follows:

Schoellkopf Aniline & Chemical Works, Inc., Buffalo, N. Y. (National Aniline & Chemical Company selling agents).

The Hudson River Aniline Color Works, Albany. (Bayer Company selling agents).

Heller & Merz Company, Newark, N. J.

Central Dyestuff & Chemical Company, Newark, N. J.

W. Beckers Aniline & Chemical Works, Brooklyn, N. Y.

When the war started, and the shortage of foreign goods became apparent, these firms were overwhelmed with orders from American consumers for supplies. For reasons which I have already mentioned, viz., their inability to get raw material from Europe, they were not able in the beginning to increase their production, and were compelled to use only the raw material which they had on hand, and when this was exhausted had to give up some colors entirely. In the meantime, however, some of them have commenced to manufacture these intermediate products, and the rest will undoubtedly do so as quickly as possible. Although I cannot speak specifically for any other factory, I can say that our own factory, Schoellkopf Aniline & Chemical Works of Buffalo, by the first of January will be making largely its own raw material, and this, together with what raw material we can get from other manufacturers, has en-

abled us to insure ourselves of a supply of raw material, so that we have increased our regular aniline products to the extent that by the first of January we will be producing something like 800,000 to 1,000,000 lb. monthly, or, say, 10,000,000 lb. annually, which is about four times our former production. While, as I have just said, I cannot speak specifically for other factories, I have no doubt that they are making equal improvements and will show equal increase in production in the course of time.

It is my opinion that an immediate development in the aniline color business in this country will depend entirely on these five original makers, as they are all equipped with capable and experienced men, who are able to direct much larger production than they are now getting and to manufacture successfully, which is a great advantage they have over new factories which may enter the field, who have not had the experience and necessary scientific help to develop the business quickly; and these factories, while having no connection one with another and no conventions nor understandings of any kind, are a unit in declaring that they must have additional protection in order to develop their business to an extent which would take care of the consumption of the United States.

Other large corporations, like the E. I. Du Pont de Nemours Powder Company, the General Chemical Company and Thomas A. Edison, have been recently mentioned as about to enter the manufacture of aniline colors, but I question if they have any intention of doing so in the immediate future, as their present business is so large and the demands upon them so severe that they will hardly be able to entertain taking up new lines in the near future, another difficulty being the inability of any of us or them to secure at present enough raw materials to manufacture even the amount of colors we could manufacture if raw materials were plentiful. For instance, one article, oleum, which is a concentrated sulphuric acid, and which enters largely into the manufacture of colors, is almost unobtainable owing to the enormous increase in its demand, due to present war conditions, which require large quantities of it for explosive purposes, and unless sufficient quantities of it could be secured the development of the manufacture of colors could not be carried on by anybody.

Of course, the present aniline works have arranged for their supply of this product now in advance, so have enough in sight to enlarge their production to the extent which I have mentioned; but for a new concern to start in at this time, I think it would be impossible for them to get this, as well as other raw material, which is absolutely necessary, and for this reason, as I said before, I think it rests with the original five color makers to develop the business for the relief of consumers, and while other concerns like those mentioned may enter the field later, it certainly will not be in time to improve matters much for a year at least.

Two other concerns have been mentioned prominently in the papers of late in connection with the actual manufacture of aniline colors, as distinct from those mentioned as manufacturers of intermediates, both concerns claiming to have new methods which are different from the methods used by the older manufacturers in their production. One of them is the Pearsite company, mentioned above, and the other is the American Co-operative Dyes & Chemical Company, Bangor, Pa., who claim to have a new method for making a hosiery black and some other colors of similar nature, and which is now in the course of formation. These two companies, however, are not known to the trade as manufacturers of colors, and the success of their new methods is, there-

fore, more or less problematical, and the future only will show whether or not they will be successful in their lines.

Aniline Oil.—Until about three years before the war this very important product for the manufacture of aniline colors, and for producing blacks directly through oxidation in dye houses, was not made in the United States, and was furnished almost exclusively by Germany and England, being in the hands of a convention which controlled the price and conditions. About four years ago the manufacture of this product was commenced on a fairly large scale by the Benzol Products Company, now at Marcus Hook, Pa., whose sales agents are the General Chemical Company, who began with a production of about 1000 tons, the whole annual consumption of the country at that time, by the way, being about 4000 tons. This Benzol Products Company did not make much progress financially, owing to the fact that even when a tariff of 10 per cent was placed on this product the foreign convention immediately reduced their price accordingly, that is, assumed this duty and still sold to their consumers here at the regular prices, and such prices did not leave the Benzol company any profit, for they could not manufacture as cheaply as the Europeans were willing to sell for.

At the beginning of the war, however, the imports from Europe stopped suddenly, and the demand for aniline oil became very acute. The Benzol company immediately took the situation in hand and arranged to increase its production as quickly as possible, and has recently completed a new factory, so that it has increased its production very materially, and eventually will reach about 5000 tons, which will be more than the entire consumption of the country under normal conditions, although the consumption will be increased very largely by the probable development in the manufacture of aniline colors, which is the largest use.

This is the concern I have mentioned as having been so fair in making contracts with its customers, that those who have bought from it have not had to pay the exorbitant prices asked by outsiders, and it is to its great credit, therefore, for working directly for the benefit of American consumers without the possible abnormal profit which it might have secured had it wished to take a different position.

In addition to the Benzol Products Company, there have a number of firms started up since the war to manufacture aniline oil, and some of these new factories have already started to deliver, but even at that the total production is not yet large enough to supply the demand. But the point is that in the end enough aniline oil will be manufactured in America to supply the demands of all consumers, so that if properly protected by tariff it will make this country independent of Europe for its supply of this product.

Benzol.—This is the basis product for the manufacture of aniline colors and products, being used, however, largely for other purposes as well as for explosives. Before the present war the normal production in the United States was about 3,000,000 gal. Since the war, owing to its suddenly increased demand, many steel companies and other similar industries who could recover benzol from their other operations immediately began to do so, so that now it is estimated that the production of benzol for 1916 will be upward of 15,000,000 gal., or about five times the original production. Owing to the enormous demand for it from explosive manufacturers, and for export to other countries, the supply in this country, in spite of the increase, remains insufficient, and very high prices are asked. But the important point is that this large production is now assured, and whenever the foreign demand ceases and the de-

mand for explosives ceases the United States will have ample production of benzol from which to build up her other industries which depend upon it; for instance, the manufacture of aniline colors and other similar products, and inevitably in view of the large supply the prices should not be any higher than those paid by foreign manufacturers for the same product.

Carbolic Acid.—This is an article which has a large consumption in the United States, some 8,000,000 to 10,000,000 lb. per annum, but which before the war was not manufactured here to any extent, because American manufacturers could not compete with the German and English. Since the war, however, many plants have been put in and practically all that is consumed here at present is manufactured in this country. Thomas A. Edison alone, who was an enormous buyer before the war, now manufactures 12,000 lb. daily, according to his interview given in the *Journal of Commerce* of July 30, most of which, however, he requires in his own works, so that he does not have much for resale. Other manufacturers are making it mostly for the making of picric acid for export, but after this demand for picric acid is over then the manufacture of carbolic acid will continue here in large quantities for domestic consumption, and the country should then be independent of Europe for its supply. This is another article which is also used in the manufacture of aniline colors, and will help their development.

Indigo.—There is now being built in Charleston, W. Va., a factory for the ostensible purpose of manufacturing caustic soda and chlorine products. It is, however, being built and controlled by a firm which is the agent for one of the largest indigo manufacturers in Europe, and who, I am informed, have all arrangements made to make indigo if it can be done successfully here, which it can in every way, except possibly not as cheaply as in Europe. With a proper protective tariff, however, this plant could be fully completed for the manufacture of indigo, and surely it would be a great relief to American consumers, who use about \$1,250,000 worth annually, to have a plant in this country from which they could draw their supplies and be assured of them in the future.

Intermediate Products.—These products were practically all imported from Europe prior to the war, but since the war factories have been started for their manufacture, so are now produced in this country such articles as beta naphthol, paranitraniline, diphenylamine, dimethyl-aniline, H-acid, benzidine, chlor-benzol, and some others, with more to come, all of which being used particularly by the aniline color manufacturers, although incidentally in some other lines; so again, if these new factories are protected by sufficient tariff, the manufacture will go on successfully and we will again be independent of Europe for our supplies.

Naphthalene.—This is another coal tar product which has increased very largely by reason of the present conditions. Before the war the production in this country was about 2,500,000 lb., while now it has increased to something like 7,000,000, perhaps more, the normal consumption being about 9,000,000 lb., and the difference between what was produced in America and the total obtained from England and Germany, which hereafter they should be practically unable to ship over here by reason of the new large production here, and which should be sold in normal times at as low prices as could be sold by Germany and England. This is also a very important intermediate product for the manufacture of aniline colors, and again a help in this production.

Sulphur Black.—This is a color used largely for hosiery and cotton purposes, and which never before

was manufactured successfully in this country, or rather could not be manufactured cheaply enough to compete with European products. The probable consumption of it is 4,000,000 or 5,000,000 lb. annually. Since the war our own concern has taken up the manufacture of this color successfully and is now furnishing the goods to consumers. We are rapidly increasing our production so that we will probably produce 2,000,000 lb. or over in 1916, all of which is practically sold on contract. Two other manufacturers have also taken up its manufacture, and are making contracts over the same period, so that it is probable that in 1916 the total amount of sulphur black manufactured in the United States will equal the former import from Europe, and with a proper protection in the tariff this large volume of business could be retained in the United States against all foreign competition.

What Tariff Protection Would Accomplish

You will see from the above that there is something actually being done in the United States in the development of coal tar and allied products, and no matter what happens in the future a large increase in this production will be assured, but I must repeat once more that if it is to be developed to the extent of supplying the whole amount of dyestuffs needed in the country which have heretofore been imported, it must have help from the Government in the way of an increased tariff, and the help of every consumer should therefore be given to bring about this very desirable result.

I wish to impress upon you in connection with the above list of what has been done, that on many of the products we are already producing in this country the normal consumption of the country, and this production will be kept up if properly protected. A notable exception to this statement, however, is aniline colors, which are so badly needed, but which, owing to their variety and the complicated formulæ and range of raw material necessary to make them, as well as the large amount of capital necessary to manufacture them in a large way, have not been developed to the full quantity needed. But even with these disadvantages, my remarks show that all of the five factories mentioned are making every preparation for development to the best of their ability, and I believe, in spite of the difficulties against them, that by Jan. 1, 1916, when they will all commence to get the benefit of their new installation and increase, they will be producing anywhere from three to four times their former production, which is a very important increase in itself.

I make bold to say further that if these factories were assured of protection they would increase their production still further, and to such an extent that within a year they could furnish the entire amount of colors required by American consumers, and so relieve them once and for all of their dependence upon European manufacturers. When I make this statement I do not mean that they can make every color which has been imported in so short a time, as there are a number of specialties which have some particular advantage in application, fastness, or something of that sort, and require a special raw material, which they would not be able to take up so quickly, and again there are a few colors which are still patented. But what I do mean to say is that they could make the colors necessary to furnish consumers every quantity and every shade which might be required, that is, give them something which they could use in place of the specialties already mentioned, the latter being what we might call luxuries and dispensable until such time as they could again be resurrected or again imported from Europe, as there can be no question but that some colors would probably al-

ways be imported no matter what the American manufacturers are able to do.

Such an assurance of protection would also probably mean the establishment of branch factories in this country of the European factories, as they would not want to lose their business over here, but the establishment over here of such factories would be welcomed by American factories, because they would then have to work under the same conditions that we do, and would not have any advantage in the cost of manufacture. Again, this assurance of protection would probably stimulate the starting of new American companies who would then be willing to advance the capital necessary and take a chance of being successful. So that even if the five original factories mentioned could not live up to the statements I have made as to their ability, they would undoubtedly have lots of new help, and the result would be ultimately the same, viz., the manufacturing in this country of all colors which are needed for its consumption.

The Possibility of Government-Owned Factories

In closing, I might say, however, that there is one thing which might be done in lieu of an increased tariff protection and which has been suggested before in different forms, but which is so reasonable and simple that I do not suppose it will be considered by our political leaders and parties, and that is, the establishment by the United States of a factory or series of factories for the manufacture of the intermediate coal tar products needed by the color manufacturers, and an arrangement to sell same to them at the same prices which are paid by the German manufacturers, even though there might be no profit or even a possible loss to the Government in doing so.

In addition to this great relief to American color makers, the Government, however, would have the greater purpose in mind of having plants already established capable of manufacturing ammunition in case of war, the point being that the raw materials used by color makers are very much the same as those used in the manufacture of various kinds of ammunition and explosives, and certainly such a factory or series of factories would be a very valuable asset for the Government.

I believe it is true that other governments take an interest in and control to some extent their natural resources; for instance, Germany is interested in her potash and coal fields, Japan in her production of camphor and menthol, and other governments in other products. Therefore it is not out of reason that the United States Government should take a parental interest in its great benzol production, and the use of same for such purposes as the manufacture of aniline dyes for its American consumers and the manufacture of explosives for its own protection should it become necessary. Certainly such a matter is well worth considering by our administration if it is impossible to secure added tariff protection on the lines mentioned so many times in this address.

The South American Handbook, published by the National Foreign Trade Council of 64 Stone Street, New York City (76 pages, price 25 cents per copy), gives detailed information relating to government finances, railway development and foreign trade of the different South American countries. It also contains a report of the Latin-American trade committee on policy required for extension of our commerce and should prove of value to those interested in the development of United States trade with South American countries.

Slime Agitation and Solution Replacement Methods at the West End Mill, Tonopah, Nev.¹

BY JAY A. CARPENTER

This paper deals with only one step in the treatment of ore at the West End mill; not because the other steps are repetitions of practice in other mills, but because in this particular step there is in use the Trent agitator. This device, although it has apparently failed in many mills, is here giving excellent service and has proved to be well adapted for making a thorough replacement of pregnant solution with a minimum amount of barren solution. The strong and weak points of this agitator, its present simple construction, and its use as a thickener for agitator or battery pulp are features of interest; but perhaps the point of greatest interest to the metallurgist in this day of continuous decantation is its use in a series of tanks for slime treatment by the replacement method.

The agitating department of the West End mill consists of six redwood tanks, 24 ft. in diameter, 18 ft. high, each equipped with a Trent agitator, a centrifugal pump, and a motor. The pulp is transferred by a pump from the top of a flat-bottomed tank to a set of arms and nozzles in the bottom of the tank, at just sufficient pressure to cause the arms to revolve. The streams from the many nozzles keep the bottom of the tank clean, and these streams, coupled with the effect of the revolving mechanism and the ascending current, keep the pulp in constant motion and of constant gravity.

These agitating tanks hold 90 tons of dry slime and 202 tons of solution with a 1.24 pulp, our ore having a specific gravity of 2.7. This capacity is about 10 per cent in excess of the standard 15 by 45 ft. Pachuca tank. The tanks are connected in one series for continuous agitation, the pulp for each agitator being drawn by its pulp through a branch suction from near the top of the preceding tank and delivered to the bottom of the tank by the agitator arms along with the regular pulp of that agitator. This method works automatically, since the flow through the branch suction varies directly with the difference in head of the two tanks. The chance for new pulp to pass out quickly is, therefore, much less than in many other systems of continuous agitation, since the new pulp is delivered at the bottom of the tank, and the discharge from the tank is near the top; the ascending current is uniform and slow.

The pulp is delivered to the first agitator of the series at a gravity of 1.26 by a set of diaphragm pumps, which raise the pulp to a height of 10 ft. above the top of the battery-pulp thickeners, whence it flows first in an open launder and then in a pipe to the suction of the first agitator pump. At intervals in the open launder are placed pieces of battery screen at an angle, which, with those placed at the lip of the diaphragm pumps, catch and remove nearly all the lime scale, wood pulp, and like material from the slow-traveling thickened pulp.

The pulp from the last agitator is raised by an air lift to a Dorr thickener, 28 ft. in diameter and 22 ft. deep, where the pulp is thickened before filtering.

The slaked lime and half the lead acetate are added direct to the scoop box of the tube mills, while the greater portion of the cyanide and the rest of the lead acetate are added at the lip launder of the diaphragm pumps; the remainder of the cyanide is added in the third agitator. For heating the pulp, live steam is introduced into three of the agitators, Nos. 1, 3, and 5, the purpose being to keep the temperature during agitation

¹A paper presented at the San Francisco meeting of the American Institute of Mining Engineers, September, 1915.

around 100 to 120 deg. Fahr., in order to hasten extraction and obtain good extraction with the use of lower-strength cyanide solutions. These high temperatures are readily maintained in a Trent agitator and are not uncomfortable to the operators, since the heavy coat of foam on the agitators acts as an insulating blanket, keeping the pulp from radiating its heat or moisture, as it does in many other types of agitators. The condensed steam adds to the tonnage of mill solution, but it freshens the solution by dilution of impurities and it is needed to replace the solution that is mechanically lost from the filter.

Once a day, at 4 a. m., pulp samples are taken from agitators Nos. 1, 3, 5, and 6, which are thoroughly washed and dried and made ready for the assayer at 7 a. m. Normally, these assays show respectively 50, 25.5, 19 and 15 per cent of the valuable content of the agitator heads.

Air for the proper aeration of the pulp is compressed to 16 lb. in a compressor of 100 cu. ft. piston displacement, and is fed into the discharge pipe of the agitator pumps. By the time the air is discharged from the

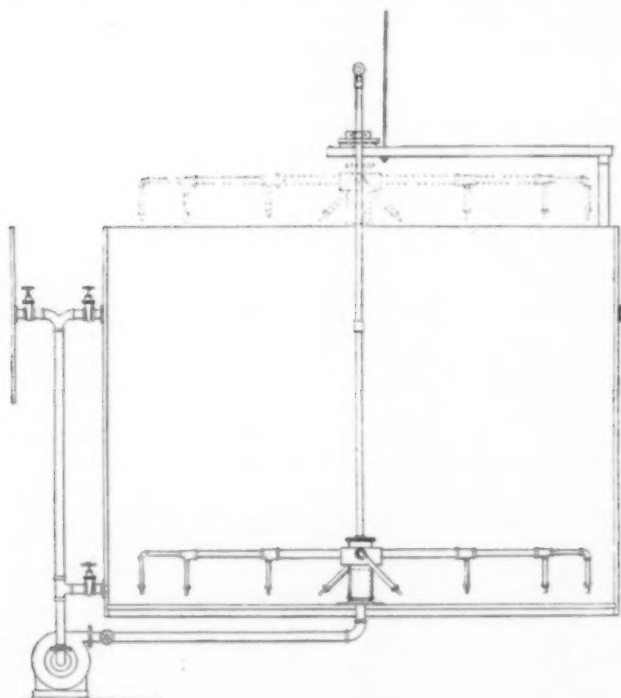


FIG. 1—TRENT AGITATOR, CARPENTER TYPE

nozzles it is thoroughly dispersed in the pulp as minute air bubbles. These air bubbles slowly make their way to the surface and escape into the foam. This well-distributed aeration, in contrast to the short contact of pulp with air in any air-lift type of agitator, is much in favor of the Trent. The pumps of the agitators can be made to suck their own air by throttling the main pulp suction, but in a large installation it is probably more economical to use an air compressor.

Modification of Original Trent Agitators

The original agitators as installed in 1911 were of the Trent underfeed type, with the large grit-proof bearing in the bottom of the tank and with the arms fitted with fifteen $\frac{3}{4}$ -in. nozzles. While these agitators gave excellent service, there was a gradual wear, which necessitated repairs on the grit-proof bearing, due to absorption of the air in the air chamber and consequent rise of slime pulp to the ball race. An occasional cleaning of the nozzles was also necessary, due to their choking

with bits of wood pulp, waste, and chips, as a nucleus, surrounded and packed tight by sand from the pulp. On a charge system these repairs could be taken care of easily when the tank was emptied, but when the continuous system was adopted it was necessary once in two or three months to empty each agitator into the following unit by the aid of the transfer pump, and make these repairs, to avoid the danger of an agitator stopping at a time when there was not room in the mill circuit to empty it.

The author, after seeing a Trent agitator suspended from a ball race at the Tonopah Extension mill, because the lower submerged ball race was worn out, conceived the idea and built a new type of this agitator which could be raised, cleaned, and dropped back into position without disturbing the pulp level in the tank. It consisted of a ball race, on timbers over the center of the agitating tank, from which the agitator mast, built of 3-in. pipe, was suspended, a collar clamped around the upper projection of the pipe resting directly on the ball race (Fig. 1).

At the same time, the large upper and lower castings, weighing 800 lb., were discarded, and castings weighing 300 lb. were substituted, which were fitted with extra heavy pipe nipples to serve for the slip joint between the stationary pump discharge and the revolving arms. The upper nipple was of 8-in. pipe, 12 in. long, and was made bell-shaped at the bottom. The lower nipple was of 7-in. pipe, 10 in. long, chamfered at the top. These nipples, after a skim cut in the lathe, have $\frac{1}{64}$ -in. clearance between them and about a 9-in. contact, which allows only a small flow of pulp to pass between them, but permits the agitator to be raised 9 in. before disengaging. An eye bolt was fastened in the roof directly over the center of the tank, and by means of a chain block the agitator is readily raised above the top of the pulp, where every part of the agitator, excepting the 7-in. nipple in the base casting, can be inspected, cleaned and repaired if necessary. Due to the balanced arms, the bell-shaped nipple, the plumbed point of support, and the guiding ball race, there is no difficulty in lowering the agitator and again engaging the nipples.

The first agitator of this type was placed in commission on Oct. 20, 1913. On account of its lighter weight, it traveled faster and put very little weight on the ball race, as the upward reaction from the nozzles nearly counterbalanced the weight. It was raised, cleaned, and lowered with ease. The tank was emptied at first every couple of months to examine the nipple wear, which was found to be very small. The original pair of nipples, after 19 months' service, are still in use and the wear has not affected the speed of the agitator.

After a thorough trial this new type of agitator was placed in all the tanks at convenient times. It has never been necessary to empty an agitator tank because of failure of the agitator of this type to revolve or keep the pulp agitated. The oldest agitator of this type had operated 10 months (on May 15, 1915) and three others nine months without lowering the pulp in the tank; and, judging from the speed of rotation and the feel of the bottom of the tank, they are good for months to come. When the agitator has been in operation for from four to eight weeks a rod drawn along the tank bottom will strike ridges, which are indications of choked nozzles. After raising the agitator and cleaning out an average of a half-dozen choked nipples, the agitator is lowered to within 6 in. of its usual depth until the cleaned nozzles have cut away the ridges. These agitators have been shut down for hours at a time and have started off after a few minutes' aid in making the first revolution.

This new type of agitator has now been adopted by

the Trent Co. as its standard design, adding to the previous good points of this agitator those of simplicity, durability and reliability.

The pump used on the agitator is a 4-in. centrifugal, driven by a 10-hp. motor. This pump, made by a local foundry, is lined, and has a white-iron open runner. The liners have given an average of eight months and the runners and shafts of six months; the cost of upkeep of the pump is about \$5 a month. At first the pumps were driven at 525 r.p.m. and required 6.5 hp. At present the speed is 460 r.p.m., taking 5.8 hp. and keeping the pulp all of the same specific gravity with the aid of the 1.2 hp. used for compressed air. The speed can be dropped to 360 r.p.m. with good agitation, but not with the constant specific gravity desired for continuous agitation. There is often a false economy in cutting power costs of grinding or agitation a cent a ton, with a probable consequence of twice that loss in extraction. The actual power used, figured as motor input, is 7 hp. per agitator, or about 1 hp. for each 12 tons of ore or 42 tons of pulp. At the Goldfield Consolidated mill 200 tons of ore in a 1.5 to 1 pulp has been agitated for $7\frac{1}{2}$ hp. or 1 hp. for $26\frac{2}{3}$ tons of ore or $66\frac{2}{3}$ tons of pulp.

Causes of Failure of Early Agitators

Several of the earlier failures of the Trent agitator were due to too small an area of nozzle discharge and to improper sizes and speeds of the pumps used. The following tests will illustrate some of the points governing the Trent agitator. With the agitator equipped with $1\frac{3}{4}$ -in. nozzles, with the pump running at 450 r.p.m., and with 3 ft. of pulp in the tank, the pressure on the pump discharge was $7\frac{3}{4}$ lb. With the pump stopped, the pressure from the static head on the discharge was $1\frac{1}{2}$ lb. The actual increase of pressure, due to the pump, was $6\frac{1}{4}$ lb. With the pump running and the discharge valve slowly closed, the pressure increased to 15 lb. and the power decreased one-half. With the agitator run under similar conditions, but equipped with $1\frac{1}{2}$ -in. nozzles, giving four times the discharge area, the pressure on the discharge pipe was $2\frac{1}{2}$ lb., or only 1-lb. increase of pressure above the static head; yet the agitator turned at the same speed of 2 r.p.m. and the motor input of 5.6 hp. remained the same.

The reason for the power remaining the same is that a centrifugal pump, running at a given speed, takes approximately the same horsepower for a wide range of heads, but the efficiency, it is to be remembered, varies greatly within this same range. The reason for the agitator running at the same speed is that the greater volume pumped in the second case, acting under less pressure, exerted as much turning force as the lesser volume under greater head.

Figuring from nozzle formula, the quantity discharged in the second case was twice that in the first case, giving, therefore, twice the upward velocity in the tank. The stronger the upward velocity, the more uniform the specific gravity of the pulp. It is evident, therefore, that a large nozzle area, with a pump designed for handling a large volume at a low head and slow speed, is the best combination, and such a pump, made along the lines of the modern Traylor sand pump, should not need repairs for a period of a year. In both the above cases, as the agitator was filled from 3 ft. in depth to 17 ft., the pressure on the pump discharge increased, but nearly in the same amount as the static head, giving the same difference or actual working head, the same power, and the same agitator speed. Consideration of these points takes the successful installation of this agitator and its pump out of the realm of guesswork.

Replacement of Pregnant Solution

At times, when the mill heads were high, it became necessary to replace pregnant with barren solution. The battery-tank solution fed to the glands of the pumps acted as an increasing diluent in the continuous circuit, but did not remove pregnant solution. The top suction of the agitator is about 4 ft. below the top of the tank, and by cutting off the air to the agitator this top 4 ft. becomes a static thickener, ending abruptly in the moving pulp at the agitator suction line. The pulp in the tank from this line down will have a constant gravity without the aid of the air. A decanting pipe placed in this top 4 ft. of the agitator removed the pregnant solution direct to the silver tank. The decanting of a full 3-in. pipe stream can begin thirty minutes after the air is turned off.

With a crowding of tonnage for several months to over 200 tons a day, which was beyond the capacity of the thickeners ahead of the agitators, the overflow of the four 8-ft. Callow cones in the concentrating department was diverted from the thickeners direct to a well, 2 in. in diameter and 3 ft. deep, in the center of the above agitator, which was No. 2 in the series. This pulp was very thin and contained the lightest particles of the ore; yet, with all this pump flowing into the top, this agitator delivered the mill flow of ore in a thicker pulp and of a lower value of solution to No. 3 agitator than it received from No. 1, and, while keeping its pulp in constant agitation for 14 ft. of its depth, it delivered a clear stream of pregnant solution to the silver tank.

At another time for several months, with less tonnage but a higher grade of ore, No. 4 agitator was fitted with an overflow launder, and a well, 2 ft. in diameter and 4 ft. deep, to take the feed from No. 3 agitator. The agitator was run without air, with top suction closed, bottom suction open, and a bottom discharge to No. 5 agitator. The pump entered the agitator at $2\frac{1}{2}$ to 1, and was discharged at 1 to 1 to agitator No. 5, where barren solution was added. The extraction in the tank remained the same as before, when it had air, which, in my opinion, was due to the fact that the greatest extraction had taken place by the time it reached this agitator, and the air included in the pulp was sufficient for extraction.

I have known a Dorr thickener, placed in the middle of a series of agitators, to make a greater extraction than the preceding agitator. However, when the air has been cut off No. 1 Trent agitator in our series, only half the usual extraction has been made. The No. 4 agitator pump on this work was cut to 340 r.p.m., taking 3.5 hp.; yet the agitator started up in its 1.45 pulp after a shutdown as rapidly as the other agitators with only 1.25 pulp. The reason for this is that as the gravity increases the viscosity also increases, hindering the settlement of the heavier sandy particles, which are further handicapped by a diminished difference in gravity between themselves and the surrounding pulp. On this basis, with a proper thickening of the pulp, pyrite concentrate can be readily agitated in a Trent agitator, as is being done at present at the Original Amador Consolidated Mines Company mill at Amador, Cal.

The next and final step in replacing of solutions was proposed to us by L. C. Trent, the inventor of the agitator. The idea was to feed to the agitator pump a ton of barren solution for each ton of ore fed to the tank, to overflow from the tank the whole tonnage of solution fed to it, and to discharge a 1 to 1 pulp from the bottom of the tank, the solution in which should be the barren solution fed to the pump.

This was to be secured by feeding the new pulp to a distributing umbrella on the surface of the pulp in order to feed it in a thin sheet, traveling nearly horizon-

TABLE I

Time Date Shift	PULP FEED												OVERFLOW SOLUTION			13 Ft. VALVE		9 Ft. VALVE		4 Ft. VALVE		PULP DISCHARGE									REPLACING SOLUTION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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tally, and by having the bottom suction draw pulp from all over the tank by means of a perforated bustle pipe inside the tank, these two doing away with all strong currents. A bypass between the discharge and the suction of the pump would regulate the speed of the agitator, and a series of manifold valves would regulate the flow of barren solution to the pump. A 1 to 1 pulp would be established in the bottom 6 ft. of the tank, and above this a sharp change to thin pulp, and then to clear solution at the top of the tank. The new pulp entering the tank would enter on the surface, only causing a ripple. The solid content would settle through the clear zone into the thick pulp below, but the solution would overflow into the launder, since there would be no downward current, due to the fact that as much solution was introduced at the bottom of the tank as was removed. For a similar reason, the solution fed in at the bottom would find no rising current, and, being mixed with the pulp, would be discharged as an integral part of the discharge pulp. By this method, the inventor reasoned that it would easily be possible to make a 90 per cent replacement of the dissolved silver entering the tank.

At the time of this visit, every agitator was needed for agitation purposes, the canvas-leaf filter was doing good work, and, lastly, we had little faith in making a high replacement of pregnant solution by this method, for all the many efforts along this line had been failures; and it was generally conceded that the diffusion of solutions of equal gravity took place so quickly and so completely that such a scheme was not practical. However, these replacers were installed at the Gold Cross and Imperial Reduction Company plants near Ogilby, Cal., and news of their successful operation came to us not only from the company headquarters, but from the traveling fraternity of millmen looking for a job.

In February, 1915, with a decrease in tonnage, No. 4 agitator was fitted up for a trial as a replacer. With the agitator filled with 1.20 specific gravity pulp, containing 203 tons of solution assaying 7 oz. silver, the feed of pulp and the air were cut off, and the bottom suction

opened. Three hours later, when the pulp in the bottom of the tank reached 1.36 specific gravity, a flow of barren solution, assaying 0.13 oz. silver per ton, was admitted to the pump at the rate of about 3 tons an hour. At the end of twelve hours the gravity at 4 ft. from the bottom was 1.36, at 8 ft., 1.11, and at 12 ft., clear; and the solution assays were 3.94, 4.57 and 6.97 oz., respectively. In thirty-six hours there had been added a little over 100 tons of solution, and the specific gravity at 4 ft. from the bottom was 1.34; at 8 ft., cloudy; at 12 ft., cloudy, and the overflow clear; and the solution assays were 1.79, 2.52, 6.21 and 6.6 oz., respectively. Since there was no discharge from the tank, the addition of barren solution had to be slow to keep from thinning the pulp in the bottom of the tank. The replacing action is distinctly shown by the assays. At the end of this time pulp feed and pulp discharge were started into and from the replacer. The results of the next two days' work are shown in Table 1.

The sharp reduction in the value of the ore, due to the extraction made in the replacer, makes it difficult to calculate the efficiency of the replacement, but, since most of the ore is in the bottom 6 ft. of the tank in the barren-solution zone, it is probably true that most of the dissolved silver goes out with the discharged solution.

During the second day there was more solution discharged from the tank than barren solution fed into the pump, and the effect is shown by the assays.

On the third day the agitator slowed down, and shutting the bypass did not increase the speed; yet the turning pressure of a man's hands on the ball race would turn the agitator faster. It pointed clearly to a choked suction pipe, which, with an inventor's optimism, was submerged under 12 ft. of pulp. Not being able to continue the experiment, the top suction was opened and the agitator started off at 3 r.p.m. The result of the experiment demonstrated that a barren zone could be maintained in the bottom of the tank and a high percentage of replacement made, but it also showed that

the capacity of the 24-ft. tank was limited to 60 tons of ore per day at a $2\frac{1}{2}$ to 1 dilution, in order to keep a clear overflow, and proved that the mechanical arrangement was defective.

Mechanical Defects Remedied

To improve the mechanical defects, the author designed both a new arrangement for the incoming pulp and a new suction for the replacer pump. Instead of the umbrella, a well, 2 ft. in diameter and 4 ft. deep, was placed at the center of the tank around the mast. The bottom was made solid and the sides perforated with $\frac{3}{4}$ -in. holes. An arm was put on the mast, which kept the bottom of the well clear.

The suction of the pump was carried around the outside of the tank as a bustle pipe, with the diameter proportioned to the flow. Twelve $1\frac{1}{2}$ -in. branches entered the tank at the floor level and ended at varying lengths in upturned ells. Each branch suction was connected to the main pipe by a plug cock, and each had a $\frac{3}{4}$ -in. connection for testing the flow and for connecting high-pressure water if it was choked.

On March 5, 1915, the replacer was started again with these changes. The new well still introduced the incoming pulp horizontally, but below the surface, giving a greater distance down to the slime line at the overflow launder. The new suction made it possible to test and keep open the twelve suction ports at all times, and left nothing inside the tank to give trouble. The agitator, being the new style, was capable of being raised out of the tank for cleaning the nozzles, and for repairs if necessary, and dropped back without affecting the solution zones in the tank. In starting the experiment, the introduction of the barren solution, as before, gradually established a barren zone, or, rather, in this case, a zone of low grade at the bottom, increasing value upward in the tank. This suggests a method for very small plants, such as used on old dumps, of using the replacer as a thickener first, an agitator second, and lastly as a replacer, discharging after making a second replacement with water. After establishing the barren zone, the feed into and discharge from the replacer were started, and the results obtained are shown in Table I.

A detailed study of the table brings out many interesting features of the replacer. A feed of replacing solution considerably in excess of discharge solution for the period of a shift results in a marked lowering of the solution value in the thick pulp and a decrease in that of the thin pulp, while the opposite condition of feed will increase the value likewise. The sharp change in the silver content of the solution is between the thick 1 to 1 pulp and the thin pulp above it, for the reason that the diffusion in the thin pulp is rapid. Hence, there is no advantage, in installing a replacer, in having any more depth above the 6 ft. of thick pulp than is necessary for the settling of the ore. It is possible to discharge the pulp thicker than 1 to 1, but it takes more power applied to the pump to turn the agitator. With a positive drive overhead, taking very little power, the pulp could be discharged as an 0.8 to 1 pulp or thicker with better replacing results.

In order to calculate the replacement of solutions in these tests, two methods are used as checks: First, dividing the ounces overflowed by the ounces fed; second, dividing the ounces discharged by ounces fed. However, before doing this, the ounces extracted from the ore and the ounces fed in with the replacing solution should be divided between the ounces overflowed and ounces discharged. These two items amount to considerable in our tests, because we were not equipped to add barren solution, and, secondly, the ore still lacked suffi-

cient agitation to be ready for filtering. Since the replacing solution is fed to the bottom of the tank, and assays show that it remains there as a partly barren zone, and since over 90 per cent of the ore is in the bottom half of the tank and a large part of it in contact with the barren replacing solution, it is fair to presume that over 80 per cent of the replacing solution and ore extraction go out in the discharge and 20 per cent reaches the overflow.

In the first test, 27 oz. of silver was introduced with the replacing solution, and 112 oz. of silver was yielded to the solutions by the ore, or a total of 139 oz., 20 per cent of which is 28 oz. and 80 per cent 111 oz. Silver to the amount of 2345 oz. was fed with the pulp solution, and of this 2219 oz. less 28 oz. was overflowed, giving 93.2 per cent replacement. Figuring by the second method, of the 2345 oz. of silver fed, only 310 oz. less 111 oz. of it was discharged, giving 91.5 per cent replacement.

In the second test 43 oz. of silver was introduced with the replacing solutions and 158 oz. of silver derived from the ore. The silver fed with the pulp solution was 3708 oz. and of this 3416 oz. less 40 oz. was overflowed, giving 93.2 per cent replacement. Figuring by the second method, of the 3708 oz. fed, only 335 oz. less 160 oz. of it was discharged, giving 95.3 per cent replacement.

In actual practice there is always a little silver in the replacing solution, and, as has been found in the continuous-decantation method, there is always an extraction from the ore, no matter how long it has been treated before decantation. These items were not considered in the foregoing calculations, as they were exceptionally high under our conditions. Again, in the tests, 11 per cent more replacing solution was added than was discharged, which could not be done with the final water replacing, due to the building up of solution tonnage.

Conclusions Drawn from Experiment

However, it was established to our satisfaction:

1. That replacing with the Trent apparatus is practicable.
 2. That it is easy to control and regulate the replacer; the one important factor being to regulate the solution fed to the pump and that discharged from the replacer. In a plant designed for this system this would be a much easier matter than in our case.
 3. That on a quick-settling pulp it would handle a remarkably large tonnage as far as adding the necessary barren solution is concerned, but that on a pulp carrying a fair percentage of light, flocculent slime it is limited in tonnage to the rate at which the light, flocculent slime will settle in a neutral or no-current tank. In a Dorr thickener there is a downward current to aid settling. At the new mill at Aurora, Nev., the light slime hardly settled in a Dorr thickener, and practically remained in suspension in the Trent replacer.
 4. That mechanically the replacer worked very satisfactorily, but that changes could be made to cut down the power consumed and yet make the rotating action more positive.
 5. That with a mixture of Tonopah ores, 60 tons of ore in a $2\frac{1}{2}$ to 1 pulp, with 60 tons of replacing solution, was all that a replacer 24 ft. in diameter and 18 ft. high could handle with a clear overflow and a 1 to 1 discharge.
- The use of this agitator for replacer experiments necessitated by passing all but 60 tons past this agitator, and caused a loss in extraction that made it necessary to stop the experiment without a working test extending over a few weeks' time; but the author believes the same results would have continued, as everything about the installation was capable of easy adjustment and repair.

Before changing back to an agitator, the replacer was run as an ordinary thickener with a 1 to 1 discharge, all replacing solution and gland water being cut off the pump, and the speed of the agitator cut to one revolution in five minutes. Hose lines were strung to add a large tonnage of solution to the 60 tons of ore in a $2\frac{1}{2}$ to 1 pulp. To run as a thickener and make 90 per cent replacement with a 1 to 1 discharge, the 60 tons of ore would have to be diluted to a 10 to 1 pulp by the addition of 450 tons of barren solution to the 150 tons of pregnant solution. About a 7 to 1 pulp was all that could be supplied without interfering with mill operations, but the slime line rose rapidly from 4 ft. below the surface up to the overflow launder. The 60 tons capacity of the replacer had appeared disappointing, but the test showed it to be a good tonnage on this particular ore compared with replacement by dilution; but it also confirmed the author's conviction that on an ore containing considerable flocculent slime the various replacing methods will have a strong rival in the older leaf and pressure filters that make an easily washed cake from the mixture of the flocculent and sandy components of the ore.

The great advantage of the replacer over the thickener-dilution method is in the smaller installation required, and the small amount of barren solution required compared with the large tonnage of barren and partly barren solution of the dilution method.

The main drawback to the replacer system has been, first, lack of faith in its principles, and second, lack of faith in its mechanical features.

To one that has operated the replacer it is easy to understand that in a 1 to 1 and thicker pulp, the pulp is so thick that the ore and solution are approaching a solid, and that the viscosity of the pulp is so great that the solution is not free to move above amid the ore particles, but, rather, is constrained to move with them; and that, once the barren solution is whipped into the pulp by the pump, it tends to remain locked up in it. The pump is of such a size that the difference in specific gravity between its suction and its discharge is only a couple of hundredths, so that the discharge pulp has no tendency to rise in the tank. This explains why the Trent method is a success and why other methods of adding the replacing solution directly into the bottom of a tank have failed.

The last year has brought about a marked improvement in mechanical simplicity and reliability in the mechanism of the replacer. One strong objection to it, compared with the dilution system, is the power required to operate it. However, this does not seem excessive when one considers the saving of the power that is consumed in handling and precipitating the large tonnages of solution required by the dilution methods. The author believes the power consumption of the replacer can be made nearly as low as that required by the equivalent number of thickeners, by the simple device of not depending entirely upon the pump to rotate the agitator, but to drive the agitator from overhead by a worm drive similar to that of the Dorr thickener and to use the pump more as a mixer and circulator of pulp, running it at a slower speed and with larger nozzles on the agitator. Our experience was that it required about 3 hp. on the motor to turn the agitator at only 1 r.p.m. in a 1 to 1 pulp, when a man with a 1-ft. leverage on the mast could turn it with ease. Why, then, should pump nozzle velocity be relied upon to turn the agitator when its proper function should be that of mixing the barren solution into the pulp and giving only the turning effect derived from that function? The pump, with a slower speed and lower working head, should need only annual repairs.

With these modifications, the author believes that the replacer will become an accepted machine in the treatment of slime that is not too colloidal in its nature.

Tonopah, Nev.

The Necessity of Tariff Reform for the American Chemical Industries

The necessity of tariff reform for the chemical industries was the subject of quite a number of lectures at the National Exposition of Chemical Industries, held in New York City, from Sept. 20 to 25. One phase of the problem, the necessity of a really strong and efficient Tariff Commission, was the subject of two addresses, made by Mr. HOWARD H. GROSS on the afternoon of Sept. 21, and at the meeting of the American Chemical Society, in the evening of Sept. 24.

Mr. Howard H. Gross, a banker in Chicago in private life, is the president of the Tariff Commission League. He emphasized that tariff tinkering must stop. In thirty years of "tariff tinkering" we have had five revisions of the tariff and two attempts at revision. The result has been that nobody is satisfied, that business has been periodically upset, that hundreds of millions of money have been lost and millions of workers distressed.

The tariff must be taken out of politics. This is absolutely necessary. What is needed to accomplish it is a permanent nonpartisan tariff commission, a sane tariff policy and scientific adjustment.

The Tariff Commission League has been founded to inaugurate and carry forward a nationwide campaign of education, to create and crystallize a public sentiment that will demand of Congress the establishment and permanent maintenance of a nonpartisan tariff commission of the highest personnel, with long tenure of office and adequate salaries; the commission to have broad powers covering investigation, gathering of tariff data, making reports and recommendations to Congress, hearing complaints, etc., to the end that tariff enactments shall be in the interest of all the people from the standpoint of sound economics rather than political expediency. The final decision as to rates will, however, be with Congress.

It is proposed that this Tariff Commission be composed of seven members, to be appointed by the President and confirmed by the Senate. In the make-up of the commission, one member is to represent agriculture, one industrial labor, one manufactures, one trade and commerce, one is to represent higher education and have special training for scientific investigation and research, and one is to be experienced in tariff classifications and familiar with departmental rulings in tariff matters. No one political party shall have a majority of the members of the commission. No member of Congress, or one who has served in Congress within two years, shall be eligible to appointment.

Mr. Gross emphasized that public sentiment is the strongest force in the world. What the people really want and insist upon, they will get. That is the reason why they got civil service. And they will get a real strong Tariff Commission if they insist upon it.

* * *

Another phase of the tariff reform which is necessary for the aid of the chemical industries of this country—that is, a scientifically devised protective tariff, sufficiently high and for a sufficiently long time—was the subject of a number of speeches, especially of the elaborate address by Mr. I. F. Stone, on the aniline dye situation. This is printed in full on page 663 of this issue.

Applied Chemistry*

BY L. H. BAEKELAND

It is only three years ago that a Brooklyn alderman, who, in the absence of the Mayor of New York, had to welcome the visitors to the International Congress of Chemistry, addressed them as if they were druggists or pharmacists.

After all, he made not much greater a mistake than many so-called educated men who obtained a B.A. and yet are ignorant enough of elementary scientific knowledge to imagine that the main occupation of a chemist is to analyze substances and detect falsifications.

Even in England, a pharmacist is currently designated as "chemist," while a real chemist is called an "analytical chemist."

But the European war has done much to correct some of these mistaken notions of the public at large. Our daily press has now more or less acquainted this country with the fact that in our national make-up, there is such a thing as chemical problems. I doubt, however, whether the unthinking masses have begun to realize that aside of the so-called chemical industry, practically every other industry, in fact, every enterprise, has chemical questions to contend with, and that chemical industry itself is intimately interwoven with the great network of every modern industrial or agricultural state; that the economic welfare of our country, and the health of its citizens are largely dependent on the way we utilize our chemical knowledge.

CHEMICAL WARS

The present war has been aptly called a "chemical war" because efficient work of every department of the fighting armies, from the Red Cross service to the manufacture of guns and explosives, involves incessantly chemical knowledge—and still more chemical knowledge.

But do not imagine that this is the first chemical war. The art of killing and robbing each other became "chemical" the day gunpowder was invented; at that time, however, the existing knowledge of chemistry was just of pinhead size. Napoleon knew very well how to use adroitly exact knowledge and chemistry for furthering his insatiable ambition to dominate the world; so he surrounded himself with the most able chemical advisers and scientists, and for awhile at least, he placed himself at a decided advantage over his many enemies; incidentally, he thus helped to lay the foundation for some very important branches of chemical industry.

"Les chiens ont appris quelque chose," exclaimed the Corsican conqueror when he realized that his enemies began to adopt the same means which had given him temporary mastership over them; but those whom he called so contemptuously "the dogs," finally beat him at his own game.

Ever since then, science, technology and chemistry in particular, have played a rôle of increasing importance in the armament of nations. This accounts, perhaps, for the strange fact that the really great military inventions have practically all emanated from civilians and from non-military nations like our own. If the men of the military class, essentially conservative in all countries, had been left to their own devices, they would probably still be fighting with bows and arrows—or perhaps, with the traditional sling. Nor should the pacifist blame the chemist if the latter's most beautiful conquests in science, if his proudest

discoveries, have been turned into means of relentless destruction and human slaughter. Do not reproach chemistry with the fact that nitrocellulose, of which the first application was to heal wounds and to advance the art of photography, was stolen away from these ultrapacific purposes for making smokeless powder and for loading torpedoes. Do not curse the chemist when phenol, which revolutionized surgery, turned from a blessing to humanity into a fearful explosive, after it had been discovered that nitration changes it into picric acid.

As well might you curse written speech or language or the art of printing—by which the most noble thoughts of the human race have been expressed, disseminated and preserved—if it has been used also to distribute the vilest lies and the most damnable errors.

Knowledge is like a knife: In the hands of a well-balanced adult, it is an instrument for good of unestimable value; but in the hands of a child, an idiot, a criminal, a drunkard, or an insane man, it may cause havoc, misery, suffering and crime.

Science and religion have this in common, that their noble aims, their power for good, have often with wrong men, deteriorated into a boomerang to the human race. Our very successes will threaten to devour us as long as all of us have not yet become imbued with the truth that greater knowledge, like greater possession of wealth or power, demands a greater feeling of responsibility, greater virtues, higher aims, better men.

Let us hope, in the meantime, that war carried to its modern logical gruesomeness, shorn of all its false glamor, deceptive picturesqueness, and rhetorical bombast, exposed in all the nakedness of its nasty horrors, may hurry along the day when we shall be compelled to accept means for avoiding its repetition.

Will you take it amiss if I made a digression from my subject as an answer to some repeated attacks which have been made of late by men who blame our increasing scientific knowledge in general and our chemical science in particular, for the excesses of the present European war?

THE PEACEFUL WORK OF AMERICAN CHEMISTS

But let us turn our attention to more peaceful chemical pursuits and more particularly to the chemists of this country.

Their work is difficult to understand and still more difficult to be appreciated by the uneducated or uninitiated; nor do chemists court the plaudits of an ignorant public that cannot understand them; they feel fully compensated by the results of their work if it only meets with the approval of a few of their fellow-chemists, irrespective whether it brings them financial results or not; in fact, most chemists are so much in love with their work that very often they neglect the financial side to their own immediate detriment.

Unlike the physician, lawyer, clergyman, actor, writer, artist, or businessman, the chemist does not depend on the public at large; he is either engaged in some private enterprise or he acts in a consulting capacity for a few people, if he is not engaged as professor or teacher in some educational institution. Popularity in the usual sense has little or no value for the chemist.

No wonder then that the chemists of this country, numerous and active as they are, have hardly been noticed among the daily noise of newspaper sensation and shrieking publicity—no more than a skillful watchmaker would be noticed among the hammering of a busy steam-boiler manufacturing plant.

And yet, right here in the United States, the chemical profession has taken such a root, such a develop-

*An address presented at the meeting of the American Chemical Society at Seattle, Wash., and repeated before the National Exposition of Chemical Industries in New York City.

ment during the later years, that we have here assembled at this very meeting, the representatives of our national American Chemical Society, which counts over 7000 members, by far the largest membership of any chemical society in the world, with all due respect to England, France and Germany. A society which finds it possible to spend yearly over \$100,000 on its three chemical publications, copies of which are to be found all over the world in every well equipped scientific library.

Nor is the study of the science of chemistry in this country a matter of recent occurrence. Our European friends are astonished when we tell them that as far back as 1792, there existed already the Chemical Society of Philadelphia, which was probably the first chemical society ever organized in the world; even today, some of the papers read at the meetings of that early scientific body furnish very interesting reading. Some of our American universities equipped chemical research laboratories for students as far back as thirty-five years ago, at a time when exceedingly few of the best known European universities possessed any such facilities.

Nor should we overlook the fact that notwithstanding the essentially pragmatic tendencies of our country, the United States has given to the world a Willard Gibbs, who out-theorized existing chemical theories and whose mathematical deductions are still after his death, furnishing food for profound thought to the most renowned physical chemists of Europe to whom they have opened entirely new fields in the study of chemical dynamics.

THE ANILINE-DYE SITUATION

I mention this more particularly because some of our aniline-dye consumers have taken the chemists of the United States bitterly to task and have made decidedly unfavorable comments on their abilities, because since the European war, dyes could no longer be imported from Europe. But Dr. B. C. Hesse, an American-born chemist, a graduate of the University of Michigan, has already ably answered this indictment of the American chemists. In a paper¹ full of information on this subject, which he presented at our last general meeting, but which, unfortunately, has received little or no attention from our daily press, he has clearly demonstrated that the aniline-dye consumers of the United States can have all the chemists and all the dyes they want; provided they are willing to make the necessary investments of capital and to submit to the risk of uncertain profits by starting their own dye-manufacturing establishments here in the United States instead of, as in the past, favoring imported dyes, either through personal choice, or by fostering legislation which forbids the home manufacturers to utilize such methods as selling agreements, "Kartels," or other consolidation of interests, dumping, so as to kill new competitors in the field, while making up the temporary loss by increasing the price of other products, and in general, any of the many other trade-arrangements and trading tricks freely and openly utilized by European manufacturers so as to stifle possible competition of our home aniline-dye producers.

The outcry which has been raised as to our shortage of artificial dyes is out of all proportion if we take in consideration that the annual importation of dyes and synthetic products from Germany amounts only to about \$9,000,000. As our former president, Mr. A. D. Little, pointed out, this represents about the same sum of money as the amount of candy sold annually by the Woolworth ten-cent stores.

LOCAL OPPORTUNITIES OF AMERICAN CHEMICAL INDUSTRIES

The development of any chemical industry is a matter of local opportunities; for instance, the manufacture of cellulose, as well as the industry of wood-distilling, has taken a greater development in the wood-covered sections of the United States than in Germany or any other country in the world.

The magnitude and earning capacity of the largest German chemical enterprise, however imposing they may be, look less astonishing if you take into consideration that some of these companies have been in existence for more than half a century. Much younger American chemical enterprises, which make American specialties—for instance, the Eastman Kodak Company, which sends its films and photographic papers throughout the whole world—have annual earnings decidedly greater than the most successful German chemical works of much older existence. Nor is the value of the output of our largest purely chemical companies much less important than that of the German concerns.

SULPHURIC ACID

This country is now the greatest producer of sulphuric acid, with an annual production of about 3,000,000 tons. Yet it is not so long ago that the first maker of sulphuric acid could not even find a purchaser for a triflingly small production of a few tons per week. It needed the opportunity of a home market; by and by this was created by the refining of petroleum after the discovery of our oil fields, the discovery of natural phosphates and the resultant industry of superphosphates, the use of dynamite for blasting, the development of the glucose industry, electrolytic copper refining. These and many other new industries all required large amounts of sulphuric acid, and gave this country an opportunity of developing sulphuric acid manufacturing to its present importance. In fact, the same reasoning holds good for all of our industries. I doubt very much whether the talented foreigners, who have now become proficient in chemical manufacturing, would have tied their initiative and enterprise by specializing in coal-tar-dyes manufacturing, if they had had the limitless opportunities of an immense undeveloped country like ours, to which to give outlet to their spirit of pioneering in mining, transportation, agriculture, and similar subjects, all beckoning for more urgent attention, and offering at the same time, more immediate rewards.

AMERICAN ELECTROCHEMICAL INDUSTRIES

In the meantime some of our other chemical industries better suited to our local conditions, have taken such an enormous development here as to make the United States an undisputed leader in at least some of them. Such products as the various acids and salts, aluminium, artificial abrasives, soda and caustic alkalis, bleaching powder, chlorine products, electrolytic copper, are decidedly more important in value and in economic importance than the few million imported coal-tar dyes.

F. A. Liddbury² pointed out rightly that if there had been a shortage in some of the products of our electrochemical industries in which the United States has been a pioneer, the consequences to our national economies would have been so serious that the present complaint of our aniline-dye users would have sounded like a timid whisper, compared to the bellowing lamentations of so many more important industries which would have become absolutely paralyzed. The fact is

¹MET. & CHEM. ENGINEERING, May, 1915, page 287.

²MET. & CHEM. ENGINEERING, May, 1915, page 277.

that few men realize how many industries are directly dependent on the work of American chemists.

If the aniline-dye industry has been somewhat neglected in this country, there are many other good reasons for it; not only was the possibility of reasonable profits too scant to offer special inducement to clever-headed businessmen to risk their capital in this branch of manufacturing when they had so much better choice in other channels of enterprise, but the first raw material, suitable coal-tar, was not abundantly available here as it is in Europe, for the simple reason that this country long ago discarded the older and more expensive methods of gas manufacturing generally used in Europe, and which give coal-tar as a by-product. The less expensive and simpler water-gas process, adopted in the United States, gives no suitable gas-tar; it is only of late, by the introduction of the by-product coke-ovens that we can look forward to an almost illimited supply of coal-tar.

In the meantime, the German manufacturers had every opportunity in specializing in these coal-tar industries and could afford to concentrate their efforts so as to supply not only their home consumption and that of the United States, but that of the whole world; in about the same way as the United States sends to the remotest corners of the globe, its sewing machines, its typewriters and its Ford cars.

Judging from the past history of the chemical industry in America, I have little doubt that the day it will be found profitable to manufacture all kinds of synthetic dyes here in the United States, instead of a few as is the case now, there will be little further delay in supplying the demand by a hustling and bustling home production.

In fact, it is quite possible that under present abnormal conditions, this branch of manufacturing may be stimulated to the point as to result in over-production after the war is over.

CHEMICAL RESEARCH IN UNITED STATES

If hitherto our chemists have been deficient in this special line, we can, with some satisfaction, point to better efforts in other chemical industries. For instance, it is not sufficiently known how many research chemists in our different American manufacturing establishments, are busily occupied in studying and improving manufacturing processes, nor what large sums of money are devoted every year to industrial chemical research. If we hear it constantly repeated that some of the largest German chemical companies employ hundreds of chemists and engineers, it is less known that right here in the United States, the number of chemists employed in some of our better organized chemical enterprises is scarcely less; but nobody finds it necessary to boast about it.

In fact, the most striking symptom is that so many engineering enterprises, for instance, some of our large electrical companies—although their field of action seems rather remote of chemical subjects—have now elaborate chemical research organizations, of which the record is well known by its excellent results.

Conditions were quite different some fifteen or twenty years ago; but this country has grown, and as the requirements and opportunities grew up at the same time new chemical problems arose thereby.

THE ANALYTIC AND CONSTRUCTIVE TURN OF MIND

The urgent nature as well as the magnitude of some of these new chemical problems, is shaking our chemists awake—is making new men of them. Professor Whitaker is probably right when he says that the chemists are thirty years behind the engineers as far

as method and attitude of mind is concerned, but this same criticism holds good for chemists all over the world. The fact is that the engineer was called first, and he was born centuries before the chemist, but the latter is now making up for lost time.

New conditions, new problems, are compelling the chemist to learn to tackle a proposition in a true engineering spirit and—to hitch some business sense to it. He is learning to forget thinking or acting on the test-tube plan; he is thrown more and more in contact with businessmen; he begins to realize that too one-sided theoretical considerations are sometimes more dangerous than complete ignorance and that a sense of proportion and relative values is the first requirement for good practical effort.

Here, indeed, is one of the weakest spots of the chemist. Aside from the fact that the chemical profession seems one of those vocations which have fascinated a large number of intellectual freaks, it has generally attracted men of an analytical, rather than a constructive turn of mind. Successful engineering is essentially constructive. The most urgent work for the chemist of to-day, must be constructive—he must learn how to cement together the vast amount of data which already lie at his disposal, even if he, himself, has to provide this very cement by further research.

THE CHEMIST IN OTHER INDUSTRIES

The chemist of to-day is no longer confined to purely chemical enterprises; even the most stubbornly conservative manufacturers have learned, through competition, that every industry, however mechanical be its nature, has its chemical problems. Things have changed rapidly since the day Andrew Carnegie listened with a sly twinkle in his eyes, to the fun his competitors were poking at him when he first engaged a spectacled professor to investigate the chemical problems in his iron-works. Conditions have now become reversed; to-day a steel or iron-works without a competent chemist justly provokes contempt and distrust.

Nor is the time so far distant when even our biggest railroads had not begun to realize how they missed the constant services of a staff of chemists, so as to advise them in the endless chemical problems which present themselves in the operation of a well organized railroad.

Some time ago, I visited the plant of the National Cash Register Company, in Dayton, Ohio; one of its most interesting departments was its well-equipped chemical laboratory, where no end of chemical questions relating to the manufacture of purely mechanical devices have to be studied and solved.

No up-to-date motor-car works is complete without its chemical department and the same remark holds good for all well organized engineering concerns.

In this country, the importance of chemistry has been first appreciated in its relations to agriculture. So obvious was this, that we set an example to all other nations of the world by the number of our federal and our State chemical agricultural laboratories. This, more than anything else, was the entering wedge of applied chemistry in this country, which extended later on in the Government Service, Geological Survey, Bureau of Standards, and the Bureau of Mines. Nor did the useful effect stop there. Many of our federal-chemists, our State-chemists, have left public service, to accept better paying positions in private industries; but the men trained in public service, implanted their high aims and scientific ways in some of our commercial enterprises, which needed it badly. I know of some cases where this beneficial influence changed radically the whole spirit of the commercial organiza-

tion, from its manufacturing to its selling department, and introduced instead of reckless, sordid commercialism, a spirit of fairness and efficiency which soon proved the more profitable policy.

ETHICS OF THE CHEMIST

In this and similar directions, the chemist can exercise a valuable moral influence on the community. If you think it over, you will find that the quest of efficiency lies quite close to the path of honesty, justice, and equity.

Here also the chemist has much to learn. In some instances I have been astounded at the almost child-like attitude of mind of some of our chemists who are too ready to sell their services to anybody who has a temporary use for them, irrespective of the underlying motives or purposes.

Some lawyers tell me that they never have the slightest difficulty in hiring chemical experts to defend contradictory opinions. It is quite amazing how some chemists in their eagerness of pleasing their employers will overlook their own ignorance of the most elementary principles of patent law, as well as their superficial acquaintance with the many details of intricate technical questions while not hesitating to furnish cocksure opinions which encourage infringers or industrial pirates to trespass on the rights of intellectual property of others.

Much ruinous patent litigation would be avoided in this country, and invention would be better encouraged if we had more men of the type of some well-known British electrical expert, who never hesitates in court to tell the simple and direct truth, regardless whether it kills or saves the case of his client; his statements are so highly valued and respected that the judges accept them without suspicion, and the same expert is frequently retained by the two opposing parties, whom he serves impartially, and who gladly pay him higher fees than to a mere litigation-acrobat-expert, or a chemical "ambulance-chaser."

EMPLOYERS AND EMPLOYEES

The ethics of our profession have been dealt with by the American Institute of Chemical Engineers, and have been embodied in its recently adopted Code of Ethics, which may furnish a good guide for younger or less experienced chemists. And this leads me to state that many more manufacturers or businessmen would be induced to utilize the services of chemists, if they could feel confident that in so doing they are not putting themselves at the immediate mercy of a stranger, by confiding to him facts or processes which it has cost them many sacrifices of time and money to accumulate, and the undivided knowledge of which, constitutes sometimes one of their most valuable assets. On the other hand, a chemist can hardly be of any service unless his client or employer is just as frank with him as he would be with his lawyer or physician.

However, this mooted point is easily overcome by referring to the Code of Ethics to which I have just alluded, or better by making a preliminary agreement between the chemist and his client or employer, safeguarding the interests of both parties. But in such a case, the compensation to the chemist should be made commensurate to the occasion.

This same principle holds good in the employment of chemists in manufacturing plants, where the chemist is either engaged in research or in a manufacturing capacity. An employer should not expect an intelligent chemist to render him important services without proper compensation, and in as far as the practical value of the work of a chemist can seldom be deter-

mined in advance, it will pay the employer to offer special inducements or rewards for initiative; he can well afford to give his chemist some share of the increased profits he has received through his work; to do otherwise, would be narrow-minded, short-sighted, and detrimental to the direct interests of the employer.

The work of a research chemist cannot be performed nor measured like that of a bookkeeper or a laborer; the results of his work are uncertain; delays and obstacles beset him at every turn; sometimes luck plays an important role; but good will, enthusiasm, and persistent endeavor are indispensable factors and these may be encouraged or killed by the attitude of the employer. An employer who is unfair, or who cannot arouse the respect or the enthusiasm of his chemists, cannot get the best there is in them. He must make them feel that if their work turns out well for him, they will get some decent share of compensation. Therefore, a reasonable salary ought to be supplemented by the possibility of a bonus or some share in the profits based on the earnings brought about directly by the work of the chemist.

On the other hand, the chemist must not overlook the financial sacrifices and business-risks assumed by his employer. He should specially bear in mind that knowledge or experience gathered at great cost by his employer, or through expensive factory equipment, or other facilities, have in most cases enabled him to take up his own work at an advanced stage. It would be rather unfair, unless otherwise stated, that a chemist should be allowed during or after his period of employment, to divulge or take advantage of all knowledge or information gathered around the plant in which he is engaged; or patent for his exclusive benefit, any inventions he may make on those particular subjects for which he is engaged, as long as the stimulating ideas themselves have been gathered by the very means put at his disposal by his employer. All these questions should be provided for and embodied in an equitable contract which will necessarily vary with special circumstances. But here again, niggardliness, or too great cunningness of the employer, will hardly pay. Unless his chemist be a fool—and a fool of a chemist is not worth anything—he will lose the good-will and confidence of the very man whose work is primarily dependent on these factors.

Faithful and generous observance of these conditions has brought about the most excellent results in many instances; I know that the contract system, with a salary supplemented by a bonus, or participation in profits in special departments, has been used with great advantage to all concerned, by some of the most successful chemical companies in Continental Europe, and in some of the more progressive American enterprises.

It has been objected that a contract of the kind merely binds the employer who has tangible assets, while in most cases it would be difficult to enforce it against faithless employees. But even then, a clear and well defined contract will prevent many misunderstandings which will crop up in the course of time. It has been my experience that direct dishonesty and faithlessness are merely exceptions among chemists, whatever their other short-comings may be.

THE CHEMIST AS A RESTLESS PROSPECTOR

We know where the work of the chemist begins. We can never tell where it ends, and through what unexpected ramifications it may lead. It is just this fact which adds some zest to the life of the struggling, hard-working chemist, and brings to his work frequently as much excitement as the best of sports; his hopes and disappointments can be compared to those of the restless prospector.

Pasteur, while he was professor at the University of Lille, was consulted by a local alcohol distiller about some irregularities in the fermentation processes. Little did the great French chemist dream, when he tried to solve this purely industrial problem, that by doing so, he was going to establish such an amount of new and unsuspected scientific facts, destined to upset all formerly accepted notions, not merely on fermentation, but on life, disease, contagion and epidemics; that he was about to revolutionize surgery, sanitation and medicine, and create several new departments of medical science; that he was going to save millions of lives, reduce sorrow and misery.

So little were the men of that period prepared for all these stupendous revelations that this great benefactor of the human race had to suffer most from the gibes and violent attacks of some of the best-known men of that very medical profession into which he was going to infuse new life by placing it on a true scientific basis. The history of the stubborn polemics and angry discussions at the French Academy show that, at that time at least, the imagination even of men of science could not expand to the point of perceiving that medicine and surgery were to be remodeled by the hands of a mere chemist.

Notes on Reverberatory Smelting Practice of Nevada Consolidated Copper Co.

(Editorial Correspondence)

Conditions surrounding reverberatory smelting at the plant of the Nevada Consolidated Copper Co., McGill, Nevada, differ somewhat from those at smelters treating copper concentrates from the other large "porphyry" copper properties. While the copper content of the original ore, averaging 1.55 per cent for August, compares favorably with that of similar ores, there is a greater abundance of iron sulphide which lowers the concentration ratio. This results in a low-grade concentrate—7 to 9 per cent copper—and the conversion of a low-grade matte—about 27 per cent copper—and necessitates the treatment of an abnormally large tonnage for a given output of copper. The grade of concentrate fluctuates from day to day with production from different parts of the mine; and as the smelter treats the concentrates practically as fast as produced, there is no opportunity for mixing to secure uniformity of charge. Proper fluxing is effected by varying the feed of lime rock at the roasters in accordance with analyses of current mill production.

Mr. Pomeroy¹ has published the following analyses of charge components and furnace products:

Material	Per cent Cu	Per cent SiO ₂	Per cent Fe	Per cent CaO	Per cent Al ₂ O ₃	Per cent S
Concentrates roasted.....	6.48	28.4	27.0	...	5.2	28.4
Cold secondaries	9.37	19.9	43.4	...	3.4	8.4
Hot converter slag.....	2.01	27.2	46.2	...	4.5	1.2
Fettling slimes	3.32	65.8	7.3	...	8.3	7.6
Lime rock .....	...	2.1	0.8	51.1	0.8	...
Roaster flue dust.....	5.85	40.4	15.2	0.7	6.6	9.2
Reverberatory matte.....	27.46	0.4	40.8	...	0.5	27.2
Reverberatory slag.....	0.298	42.2	28.4	9.5	6.8	0.4

Under present conditions, when every department of the plant is being pushed to capacity, the lack of ample facilities for roasting is being felt. With insufficient means for eliminating sulphur, the grade of the resulting reverberatory matte is not as high as might otherwise be obtained, and this, in turn, places an additional burden on the converters.

The roasters, which have six hearths 18 ft. inside

diameter, are making a creditable performance, considering that they were originally designed for the treatment of 50 tons each per day. They are now handling nearly twice that amount of charge. The daily average for August was 91 gross tons, consisting of 79 tons of ore and 12 of lime rock. Seventy-five per cent of the sulphur is eliminated, amounting to 15 tons per furnace day. In order to utilize the heat of the roasters as fully as possible in the elimination of sulphur, the practice has been adopted of introducing the lime rock on the fifth hearth, or next to the bottom. Some further changes are now contemplated at the roasting plant that will improve the draft and sulphur elimination, as a result of which it is expected that the grade of reverberatory matte can be raised to about 30 per cent copper.

Crude Oil for Smelting Fuel

Fuel is the main item of cost in reverberatory smelting at McGill. Here the furnaces are oil-fired, using California crude petroleum heated to between 175 and 200 deg. Fahr. There is no probability of a change from this practice to the use of coal dust, notwithstanding the excellent results obtained with the latter fuel elsewhere. A number of factors determine this decision at McGill. In the first place the cost of coal of any grade is high, while fuel oil is obtainable from California at moderate cost. Second, the excellent fuel ratios now obtained with oil, compared with those reported from other plants fired with coal dust, lead the management to believe that coal dust would show no advantage or improvement over oil. And finally, the capital and operating costs of a coal-pulverizing plant are eliminated by the use of oil, which requires no preparation other than heating. Compressed air, of course, is required for either method of firing.

The number of burners to each furnace has been reduced from seven to five, and sometimes only four may be in use. The oil is fed under static pressure of 34 lb. and atomized with air at 40 oz. Combustion is practically perfect. The maximum temperature is developed at the second side door, 21 ft. from the burners, ranging from about 2650 to 3075 deg. Fahr. The furnaces are charged through four holes in the roof, 20 to 25 tons at a time. The side walls are fettled in the usual manner, the openings being piled full of fettling material. Different fettling materials are used at various points for special purposes. Thus converter secondaries are charged along the firing wall or wherever it is desired to sink a heavy material below the slag line to act as a foundation for silicious fettling. Flotation concentrates, which are now being produced in the course of experimental work at the concentrator, are used extensively for fettling.

Recent Furnace Performance

In explanation of the following data, the term "total charge" indicates the sum of the "solid charge" plus converter slag. The "gross fuel ratio," expressed in barrels of oil consumed per ton of charge smelted, gives the total oil consumption. In order to get the "net fuel ratio," a credit must be applied for heat recovery at the waste-heat boilers. This credit is based on water evaporated, and is expressed as a percentage of a factor of 14 lb. water per pound of oil.

For the month of August, 1915, the average tonnage of total charge per furnace day was 645, of which about 15 per cent was hot converter slag. Oil consumption averaged 0.48 bbl. per ton of total charge. Applying a credit of 35 per cent for waste-heat recovery, the net oil ratio was 0.312 bbl. per ton of total charge. Furnace No. 2 had an average daily record of 671 tons and a gross fuel ratio of 0.45 bbl. of oil.

¹New York meeting A. I. M. E., February, 1915. "Reverberatory Smelting Practice of Nevada Consolidated Copper Company." By R. E. H. Pomeroy, smelter superintendent, McGill, Nev. The supplementary data on furnace operations given in these notes were kindly provided by Mr. Pomeroy during a recent visit at the plant.

On August 31, 1915, furnace No. 2, measuring 18 ft. 10 in. by 132 ft. at the skim-line level, had been in continuous operation for one calendar year, and the campaign was not yet closed. During this period the furnace treated over 240,000 tons of charge, a performance which has encouraged the management to set a new goal of a quarter of a million tons in a single campaign. The exact data on this furnace are given below.

Furnace days	358.3
Total charge, tons.....	241,053
Solid charge, tons.....	213,223
Total charge per furnace day, tons.....	673
Solid charge per furnace day, tons.....	594
Oil ratio for total charge, bbl.....	0.565
Oil ratio for solid charge, bbl.....	0.640

Furnace No. 1 is now on an unfinished campaign, the current record of which follows.

Furnace days	150.7
Total charge, tons.....	93,618
Solid charge, tons.....	79,385
Total charge per furnace day, tons.....	621
Solid charge per furnace day, tons.....	526
Oil ratio for total charge, bbl.....	0.482
Oil ratio for solid charge, bbl.....	0.608

All factors and conditions considered, it is believed that these records are among the best in reverberatory copper smelting. Naturally, they are obtained only by careful study and close attention to detail, discovering the factors that make for high or low efficiency, and augmenting the former and diminishing the latter as much as possible. No small part of the success lies in creating a good organization and maintaining the proper spirit of interest and loyalty in the operating crew.

The Estimation of Aromatic Hydrocarbons in Cracked Petroleum¹

BY W. F. RITTMAN, T. J. TWOMEY AND G. EGLOFF

In connection with the commercial production of aromatic hydrocarbons from petroleum a necessity has arisen for convenient and reasonably accurate analytical methods. Such methods may have as a basis either chemical or physical differences among the properties of the constituents of the mixtures which are produced by the cracking process. The present communication deals with the application of physical methods to the processes of separation and differentiation. Some experiments have also been performed on the chemical side of the question results of which will be published in a subsequent connection.

The following physical properties are suggested as of possible utility:

1. Solubility.
2. Melting point
3. Boiling point.
4. Specific gravity.
5. Refractive index.
6. Surface tension.
7. Viscosity.
8. "Molecular weights" (effect on boiling point or freezing point when in solution).

Of these properties the first three may permit an actual separation of the constituents of a mixture. The other can serve [at most] only as means of differentiation.

Several possibilities may be eliminated on the basis of previous knowledge. Surface tension is readily influenced by the presence of small quantities of impurities and in the absence of definite knowledge concerning the exact nature of this phenomena, is of little service. "Molecular weights" have been shown to be unreliable

even when determined for mixtures which are chemically more homogeneous than those obtained in the present work.

Refractive indices are related closely to specific gravity, and on account of that relation do not need special consideration. Viscosity is not an additive property. In actual fact, information is needed regarding only the first four possibilities of the list.

A consideration of actual conditions reveals the following state of affairs: The cracked petroleum oil is a complex mixture containing a series of aromatic hydrocarbons, of which the most important are benzene, toluene and xylene. "Xylene" represents a mixture of the three isomers, the properties of which are closely related. Higher aromatic hydrocarbons are likewise present and work is at present in progress for the purpose of studying methods for their separation and estimation. There are also present in the mixture considerable quantities of non-aromatic hydrocarbons of various classes and of almost all boiling points. From these facts it appears improbable that the desired separation and estimation may be accomplished through an application of any one property.

A method of separation which suggests itself as particularly attractive is that based on differences in solubility. Unfortunately, however, there are known few, if any, satisfactory differences of this sort. Certain asphalts are dissolved by aromatic and are unattacked by non-aromatic hydrocarbons, and this fact has been utilized for a qualitative test² for the former.

The use of liquid sulphur dioxide has many of the characteristics of a differential solubility method, but in the present connection has been classed as a chemical method.

One other solvent which is recommended as offering a satisfactory medium for separation by solubility is dimethyl sulphate. Experiments have been performed to discover the utility of this method when applied in the simple way practicable in the ordinary commercial laboratory.

A second possible method of separation depends upon differences in melting point. An examination of physical chemical tables indicates that benzene³ freezes at about 5° C., and that all the hydrocarbons which are associated with it in distillation cuts have considerably lower points of solidification. Experiments have been conducted to ascertain whether or not any simple and convenient laboratory method may be based on these differences.

The method of separation through differences in boiling point needs little discussion. That it is possible to separate benzene, toluene and xylene by the method of distillation is indicated by the differences in their boiling points:

Benzene⁴, 80° 4.
Toluene⁵, 110° 3.
Xylene⁶, 138 to 142°.

While, however, the three aromatics may be separated from each other by the process of rectification they cannot be isolated from the aliphatic hydrocarbons which are present in the cracked oil, and which have boiling points approximately the same as those of the benzene, toluene and xylene.

A convenient fact appears in the wide differences

¹Qualitative Method of Holde. Examination of Hydrocarbon Oils. Holde, Mueller, page 49.

See also Allen's Commercial Organic Analysis, Vol III, page 241.

²Lochowicz (M. P. 5° 42), Ber., 21, 2206, 1888. Paterno (M. P. 5° 53), Gazz. Chim., Ital., 27, 481, 1897. Young (M. P. 5° 55), Proc. Royal Soc., Dublin, 12, 31, 385, 1910. Richards & Shipley (M. P. 5° 453), J. A. C. E., 36, 1331, 1914.

³Kuopis, Liebig Ann. 248, 175 (1888).

⁴Landolt & Jahn, Z. Phys. Chem. 10, 303 (1902).

⁵Barbier & Rowe. Bull. soc. chim. 3255 (1890); Weegman, Z. Phys. Chem. 2237 (1888).

¹Published with the permission of the Director of the Bureau of Mines.

²Rittman & Egloff, J. Ind. Eng. Chem., vol. 7, 582 (1915).

between the specific gravities of the aromatic hydrocarbons and those of the other constituents of approximately like volatility. Table 1 indicates the wide variation.

Specific gravity may be easily and accurately determined, and through its use is suggested a possible

TABLE I.—SPECIFIC GRAVITY DIFFERENCES BETWEEN PARAFFIN AND AROMATIC HYDROCARBONS HAVING APPROXIMATELY THE SAME BOILING POINTS

Paraffin Hydrocarbons		
	B. P.	Gravity
Dimethyl Pentane ^a	86°	0.711/0°
Diisobutyl ^b (b).....	108° 5	0.713/0°
Nonane ^c	131° 5/751 mm.	0.742/12° 4
Aromatic Hydrocarbons		
Benzene ^d	80.4	0.876/20°
Toluene ^e	110.3	0.871/14.7°
Xylene ^f (o).....	142°	0.885/14.1°
(m).....	139°	0.869/15.7°
(p).....	138°	0.866/14.7°

satisfactory method of differentiating compounds which are alike in the property of volatility.

Experimental

SOLUBILITY METHOD—USE OF DIMETHYL SULPHATE

Valenta¹ has stated that aromatic hydrocarbons are soluble in dimethyl sulphate and that open chain hydrocarbons are practically insoluble. This condition, however, he limits to compounds having boiling points between 240 deg. and 300 deg. C.

Since the publication of his results the utility of this reagent has been investigated by various experimenters. Perkins and Harrison² subjected it to a number of

TABLE II.—PERCENTAGE SOLUBILITY OF MINERAL OILS IN DIMETHYL SULPHATE

	Per Cent Dissolved	Sp. Gr.	Volume Dimethyl Sulphate Used
Spindle oil.....	3.2	.....	1.5
Cylinder oil.....	.....	0.903	1.5
Russian oil.....	2.3	0.897	1.5
Russian oil.....	0.0	0.900	1.5
American oil.....	5.0	0.875	1.5
American oil.....	1.1	0.903	1.5
Scotch.....	7.6	0.885	1.5
Galician.....	7.6	.....	1.5
Petroleum ether.....	17.2	.....	1.5
Kerosene.....	3.4	0.798	1.5
Mineral oil, B.P. 160° to 300°.....	7.2	.....	1.5
Mineral oil, 160° to 300°.....	14.4	.....	2.0
Blast furnace oil.....	36.0	0.803	1.5
Blast furnace naphtha.....	20.5	.....	1.5
Blast furnace burning.....	14.0	.....	1.5
Shale oil, Pearline.....	13.0	0.865	1.5
Turpentine, Russian.....	28.3	.....	1.5
Turpentine, American.....	29.0	0.915	2.0
Rosin oil ³	24.0	.....	1.0
Rosin oil.....	44.0	.....	2.0

¹Valenta states only soluble to a slight extent. Chem. Zeitg. 30, 266, 1906.

trials and found that it dissolved percentages of petroleum hydrocarbons varying from zero up to considerable amounts. Their results are shown in Table No. 2. Table No. 3 illustrates per cent of recovered aromatic hydrocarbons, xylenes, when mixed with varying quantities of paraffin hydrocarbons. Their conclusion is that any method based upon the separation effected by dimethyl sulphate lacks value in the matter of quantitative accuracy, and that occasional good results obtained are due to fortunate accident.

¹Ladenburg, Liebig Ann., 142,310, 1867.

²Kopp, Liebig Ann., 95,336, 1855.

³Lemoine, Bull. Soc. Chim., 41,164.

⁴Kuops, Liebig Ann., 248,175, 1888.

⁵Landolt & Jahn, Z. Phys. Chem., 10,303, 1892.

⁶Barbier & Rowe, Bull. Soc. Chim., 3255, 1890; Weegman, Z. Phys. Chem., 2237, 1888.

⁷Chem. Zeitg., 30, 266, 1906.

⁸Analyst, 33, 2, 1908.

TABLE III.—MIXTURE OF VARIOUS PERCENTAGES OF XYLENE AND MINERAL OILS

Oil	Percentage Volume Xylene in Oil	Percentage Volume Absorbed	Percentage Difference	Volume of Dimethyl Sulphate Used
Spindle.....	43	36	7	1.5
Spindle.....	58	49	9	1.5
Spindle.....	43	41	2	2.0
Russian.....	23	9	14	1.5
Russian.....	35	21	14	1.5
Russian.....	33	25	18	1.5
Russian.....	46	29	17	1.5
Russian.....	22	8	14	1.5
Russian.....	46	38	8	2.0
American.....	51	41	10	1.5
American.....	27	27	00	2.0
American.....	36	29	7	2.0
American.....	51	48	3	2.0
Queens.....	17	17	0	1.5
Queens.....	47	37	10	1.5
Kerosene.....	9.6	12.5	2.9	1.5
Kerosene.....	50	43	7	2.0
Galician.....	11	12	1	2.0
Galician.....	22	16	6	1.5
Galician.....	48	36	12	1.5
Galician.....	88	84	4	1.5
Scotch.....	18	13	5	1.5
Scotch.....	47	36	11	1.5
American.....	31	28	3	1.5
American.....	41	33	8	2.0
Roumanian.....	28	33	5	2.0
Roumanian.....	59	61	2	2.0
Roumanian.....	51	52	1	2.0
Petroleum ether.....	19	24	5	1.5
Blast furnace oil.....	51	72	21	2.00
Rose oil.....	32	54	22	2.00

Chapin¹⁰ also arrived at the conclusion that dimethyl sulphate does not effect a quantitative separation, but believes that under certain conditions the results may be of value. Reeves and Lewis¹¹ have found the reagent of service and suggest that it may be of value if used in conjunction with a volatilization test. They believe, however, that more data must be accumulated. On the other hand, Sommer¹² has failed by the use of dimethyl sulphate to detect as much as 10 per cent of asphalt in oil.

Church and Weiss¹³ have studied the behavior of the reagent under the exact conditions specified by Valenta¹ and find that with coal tar and water gas tar distillates boiling between 240 deg. and 300 deg. C. dimethyl sulphate failed to show indications of non-aromatic constituents when by the sulphonation methods, amounts varying between 1.2 per cent and 6.8 per cent were estimated.

Church and Weiss arrive at the conclusion that the use of the reagent does not attain any degree of accuracy, and that dimethyl sulphate is, in addition, undesirable because it is difficult to obtain in a pure state, is unstable, and on account of its poisonous nature is dangerous to those handling it.

In the present experiments the method of application was as follows: Five cubic centimeters of the sample were measured into a 25 c.c. stoppered and graduated cylinder and 20 c.c. of dimethyl sulphate added. The mixture was shaken for five minutes, heated for fifteen minutes and shaken again.

In no case did any separation occur, even when the mixture treated was known to contain a considerable proportion of non-aromatic constituents. This discrepancy may have been due to any one of the causes indicated above, and it therefore appears that dimethyl sulphate is entirely lacking in utility for the present needs.

FREEZING METHOD

The fact that benzene crystallizes at about 5.5 deg. C. and all other hydrocarbons which might be present with it in a distillation cut about 100 deg.²¹ lower led to

¹⁰Bureau of Animal Industry Circular 167.

¹¹Jour. Ind. Eng. Chem., 5, 293, 1913.

¹²Ibid., 2, 5, 1910.

¹³Ibid., 6, 296, 1914.

²⁰Loc. cit.

²¹Toluene, M. P.—92.4. Guttman, J. Chem. Soc., 87, 1037, 1905. N Hexane, M. P.—93.5. Richter, Kohlenstoffverbindungen, I, p. 325.

the belief that this properly might be used as the basis of an analytical method. Some experiments were therefore conducted with known mixtures of benzene and a refined gasoline of specific gravity of 0.728. These mixtures were treated at three temperatures. Melting ice gave a temperature of zero degrees centigrade. An ice-salt mixture gave a temperature of -20 deg. C. A temperature of -40 deg. C. was obtained by the admixture of carbon dioxide with an excess of acetone in a Dewar flask.

At zero degrees no solidification took place with any of the mixtures, except with the 90 per cent mixture, which gave a recovery of 20 per cent, within the time of a reasonable period of treatment. In all cases the mixture was kept at the required temperature for from fifteen to twenty minutes with constant stirring. Furthermore, inoculation of the solution yielded no different results.

At -40 deg. results were obtained which show in Table 2.

From these results it appears that benzene crystals tend to include so much mother liquor that the freezing method for the estimation of this constituent is rendered unreliable. It also appears that in the presence of an excess of non-aromatic constituents the benzene crystals may be either prevented from separating out or dissolved as soon as formed. In any event the freezing method seems to have little to recommend it.

DISTILLATION METHOD

The approximate separation of benzene from toluene and toluene from xylene is not necessarily a difficult problem, as there are differences of about 30 deg. C. between the boiling points of each of the adjacent pairs of hydrocarbons. By the use of efficient and convenient

benzol and toluol, and 120 deg. very nearly half way between toluene and the lowest boiling of the xylenes.

That the degree of fractionation is sufficient is shown by the results of the following experiment: A specimen of one of the final 95 deg. C. cuts was subjected to a further redistillation, and it was found that 94.3 per cent came over below the original limit. In consideration of the fact that a complex mixture was being distilled this may be considered as a very satisfactory degree of separation.

SPECIFIC GRAVITY

For this accurate determination of the percentages of the three aromatics in their respective distillation cuts by the method of specific gravity it is necessary to know the following three values:

1. The specific gravity of the aromatic constituent.
2. Specific gravity of the non-aromatic constituent.
3. Specific gravity of the cut.

Figures for the pure aromatics are obtainable in the literature.

The following values are given by Holde:²²

Hydrocarbon	Purity	D 15°/15° C.
Benzene.....	95% boiling within 0.8°	-0.883 -0.884
Toluene.....	95% boiling within 0.8°	-0.870 -0.871
Xylene.....	0% boiling under 136°, 90% below 140°	-0.867 -0.869

Figures for the mixture of unknown composition are obtained from simple laboratory determinations. It is not as easy, however, to arrive at values for the non-aromatics. A scheme that has been used for approximate calculations in another connection (results to be published later) is to use the value obtained for a distillation cut between the same temperature limits obtained from an uncracked oil of the same type as that used in the transformation to aromatic hydrocarbons. This assumes that the properties of the non-aromatic constituents are unchanged by the cracking process. The extent to which this is true yet remains to be proved. Fortunately, however, conditions are such that an approximate knowledge of the gravities of non-aromatic constituents is sufficiently exact for present purposes. On the basis of general knowledge from various sources it has been assumed that the average gravity of these hydrocarbons in the benzene cut is 0.720, in the toluene cut 0.730, and in the xylene cut 0.760. These values are undoubtedly near the truth, but even if they are not their use permits the obtaining of results which are at least as reliable as those derived from analyses by chemical methods.

A specific illustration may serve to show the nature and magnitude of possible errors. The cuts, as obtained by the distillation method, generally ran between 60 per cent and 80 per cent benzene. The figures in Table 6 show the differences obtained by assuming for non-aromatics specific gravity figures respectively of 0.710 and 0.720.

TABLE VI.

Sp. Gr. (Measured)	Per Cent Benzene on Basis of 0.72 for Non-Aromatics	Per Cent Benzene on Basis of 0.71 for Non-Aromatics
0.816	60	62.5
0.832	70	72.0
0.848	80	81.0

The error, or rather variation, ranges between 1 per cent and 2.5 per cent on this basis. The lower values for benzene were obtained with the higher assumed gravity for the non-aromatic constituents. For the toluene and xylene cuts conditions are similar except

²²Holde-Mueller, Op. cit., p. 260.

TABLE IV.

Percentage Benzene in Mixture	Percentage by Volume Solidifying
90	100
80	100
70	100
60	40
50	25
40, 30, 20 & 10	00

TABLE V.

Percentage Benzene in Mixture	Percentage by Volume Solidifying
90	100
80	100
70	100
60	100
50	100
40	95
30	40
20	10
10	00

still-heads of the Hempel type a satisfactory degree of separation may be attained in three successive distillations, which involves a time consumption of two to two and a half hours for one operator. This procedure, while approximately separating the three aromatics from each other, does not rid them of the non-aromatic constituents with which they are associated.

The largely empirical method which has been adopted is as follows: The original cracked oil is distilled and a cut made at 175 deg. C. A portion of this cut is redistilled and divided into three portions at the limits 105 deg., 130 deg., and 160 deg. C. These cuts are subjected to a further fractionation, the temperature limits this time being 95 deg., 105 deg. and 150 deg. C. The cut limit of 150 deg. is fixed by the fact that the distilling flask goes very nearly dry at this point. The figure 95 deg. is midway between the boiling points of

that the possibility of error in assumption is even less, due to the narrower range in boiling point of the cut.

To ascertain definitely the reliability of these assumptions concerning specific gravities an extensive set of supplementary experiments was conducted. First, the gravity results were verified by a series of chemical tests performed by the authors. Present experience has led to a preference for the nitration method for the determination of benzene, this being preceded by a removal of unsaturated open chain compounds. Procedure was as follows:

(a) *Removal of Olefines.*

A 100 c.c. sample of the 95 deg. distillation cut is measured into a 500 c.c. separatory funnel. To this was added 100 c.c. of conc. sulphuric acid (sp. gr. 1.84). During the addition of the acid and the subsequent shaking for five minutes the mixture is cooled with ice water. A reddish-brown sludge forms which may readily be separated by centrifuging for fifteen minutes, although it does not settle with long-continued simple standing. The acid-sludge mixture is drawn off and the residual oil subjected to nitration according to the method of Lunge.²⁵

(b) *Nitration.*

The procedure for nitration is briefly as follows: The sample of about 100 c.c. of oil is placed in a 500 c.c. flask equipped with a dropping funnel and a tube which acts as an air-cooled reflux condenser. Into the oil is run dropwise and with constant shaking a well-cooled mixture of 100 g. of nitric acid (sp. gr. 1.4) and 180 to 200 g. of conc. sulphuric acid (sp. gr. 1.84). The flask is cooled during the addition by immersion in ice water. After the cessation of all tendency toward spontaneous heating of the mixture the flask and its contents are heated for two hours at a temperature of about 60 deg. C. The escape of vapors is prevented by the use of an efficient reflux condenser. After cooling, the contents of the flask are transferred to a separatory funnel, allowed to settle and the lower acid layer drawn off. The latter is diluted with several times its bulk of water, and any oily liquid separating is added to the nitrobenzene.

The crude nitrobenzene is washed three times with water, once with very dilute caustic soda and again with water. It is dried and weighed, then distilled up to 150 deg. and the distillate again treated with a large excess of the nitric-sulphuric acid mixture. Any liquid remaining undissolved in the acid is regarded as non-nitrifiable material.

Experimental Results

Nitration experiments were conducted upon specimens of the 95 deg. cut of such gravities that the benzene content was estimated at from 65 per cent to 99 per

TABLE VII.

Sp. Gr. of Sample	Per Cent Benzene on Basis of Sp. Gr.	Per Cent Benzene on Basis of Nitration Figures	Per Cent Difference
0.824	65.0	63.6	1.4
0.828	68.1	66.2	1.9
0.840	75.0	72.0	3.0
0.848	80.0	77.2	2.8
0.867	91.9	88.0	3.9
0.872	95.0	92.3	2.7
0.878	98.8	96.0	2.8

cent. Two or three determinations were made for each sample and results obtained which checked with variations of $\frac{1}{2}$ to 1 gram in the quantity of nitrobenzene obtained.

Results show in Table 7:

²⁵Coal Tar and Ammonium, Lunge, 4 edit. (1909), Vol. II, page 765.

In each determination the per cent of benzene found by the nitration method is lower than that indicated by the specific gravity figures. That the results of the nitration method should be low is indicated by the fact that there are unavoidable errors due to losses in washing and transference, and that there is a possibility of the removal of benzene in the course of the deolefinization with sulphuric acid. Chemically pure benzene cannot be made to yield 100 per cent of the theoretical amount of nitro-product. The specific gravity figures are undoubtedly the more accurate and the assumption of the value 0.720 is hereby justified.

A second check on the reliability of the specific gravity-distillation method was obtained through the results of several analyses made in laboratories which specialize in the examination of hydrocarbon mixtures. These worked independently on samples of a cracked oil and a 200 deg. distillation cut from the same. The latter represented about 42 per cent of the cracked oil.

Results of the analyses show in Table 8.

TABLE VIII.

Analysis Number	CRACKED OIL		DISTILLATION CUT	
	Per Cent Benzene	Per Cent Toluene	Per Cent Benzene	Per Cent Toluene
1.....	10.50	11.50	29.00	26.25
2.....	11.68	11.33	23.20	26.20
3.....	.....	.....	39.91	23.55
4.....	9.60	6.60	30.20	24.80
5.....	13.00	10.70	26.20	23.80
Average 1-5..	11.19	10.03	29.70	24.92

Analysis No. 1.—The method employed was distillation, followed by deolefinization and redistillation with subsequent determination of aromatics by the sulphonation method. Results show one slight discrepancy in that they do not indicate the same ratio of benzene and toluene in cracked oil and distillation cut derived therefrom.

Analysis No. 2.—The oils were distilled and redistilled with efficient fractionating columns and subsequent determinations made by both sulphonation and nitration methods. The latter were given the preference. Results were submitted with the statement that they were probably 1 or 2 per cent too high. Here again there is a discrepancy between cracked oil and distillation cut, and it is in the opposite direction to that noted in analysis No. 1.

The results of both the preceding analyses are probably as reliable as could be obtained by laboratories working in ignorance of the exact conditions under which the cracked oil was produced and distilled.

Analysis No. 3 was made with a single separation by distillation, followed by duplicate determinations by the methods of sulphonation and freezing. The figure for toluene is near that obtained by other laboratories. That for benzene is high, probably because reliance was placed on the results of the method of freezing.

Analysis No. 4 was submitted without statement as to method. Results are in general low, which indicates a reliance on purely chemical methods.

Analysis No. 5 was made by the authors by the method of distillation and specific gravity indicated above. The results are similar to those of analyses No. 1 and No. 2, but have the advantage of agreeing as to the ratio of benzene and toluene in cracked oil and distillation cut.

Summary

The following conclusions have been reached through the results of a series of experiments performed with the degree of care and accuracy generally feasible in commercial laboratories:

1. Solubility methods for the separation and estimation of aromatic compounds in cracked petroleum do not seem to be satisfactory.

2. The freezing method for the determination of benzene yields at best only qualitative results.

3. (a) Results approximating those of the best chemical methods may be obtained by the method of separating aromatic hydrocarbons with three successive distillations and determining their percentage in distillation cuts by specific gravity relations.

(b) The method of procedure which has seemed most satisfactory on the basis of present experience is as follows:

Seven hundred grams of cracked oil are distilled from a 1 liter distilling flask through a fractionating column whose efficiency is at least as great as that of a 5-in. Hempel column of aluminium beads. Two successive redistillations are conducted, likewise with efficient fractionating columns. For these a 200 gram portion of the 175 deg. cut is taken. For the first redistillation fractions are separated at the temperatures of 105 deg., 130 deg. and 160 deg. For the second the cuts are made at 95 deg., 120 deg. and 150 deg.

Specific gravities are then determined by whatever method seems convenient. Measurements should be accurate to about one part in a thousand. The percentage of aromatics is then calculated from these values on the basis of the following gravity relations in the various cuts:

Temp. of Cut, C.	Sp. Gr. of Aromatic	Sp. Gr. of Non-Aromatic
95°	0.880	0.720
120°	0.871	0.730
150°	0.869	0.760

(c) The one assumption upon which this method is based is the gravity value assigned in each case to the non-aromatic constituents of the distillation cut. This need not be known with great accuracy, but with our present knowledge of the mechanism of the cracking process it is desirable occasionally to verify results obtained on the basis of these specific gravities by the application of chemical methods of determination.

Chemical Section of Petroleum Division,
U. S. Bureau of Mines, Pittsburgh, Pa.

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Synthetic Phenol and Picric Acid*

BY DR. A. H. NEY

Under normal conditions the world's demand for carbolic acid or phenol is amply covered by the amounts produced by the coal tar industry and the by-products recovery of the coke oven. The recovery of carbolic acid, crude and pure, from the so-called "creosote oils," that is, from afterrun of the light fractions and the forerun of the heavy fractions of the coal-tar distillation and the alkaline washings of the naphthalene fraction, has been developed to a high degree of perfection and refinement in England, the true cradle of the organic chemical industry. Pure carbolic acid (or phenol) has found extensive applications in the arts since its discovery by Runge in 1834, who as the first isolated it from coal tar. The aniline color industry employs it as an important intermediate product; together with its homologues, the cresols, it is extensively used in recent times for the manufacture of synthetic resins, and it is the starting material for salicylic acid and picric acid.

Owing to the extraordinary demand for the latter product in war time, the supply of natural phenol is entirely insufficient; moreover the price of carbolic acid has been subject to considerable market fluctuations, while during the last decade, until the outbreak of the war, the price of benzol has remained remarkably stable. For this reason the synthetic production of phenol from a material always available in practically unlimited quantities has gained considerable importance. Chemical research, of course, has in time produced several ways for the preparation of phenol, synthetically from other materials. All these methods, however, possess no industrial importance, and I refrain from recounting them. They may be found in the literature, the references being contained in Beilstein and other reference books.

Faraday in 1826 prepared naphthalene sulfonic acid by the action of sulfuric acid on the hydrocarbon naphthalene. The technical importance of this operation, called sulfonation, was not realized until half a century later, when Wichelhaus introduced the alkali-fusion of aromatic sulfonic acid in the industry, and since that time the stupendous development of the aniline dye industry has found one of its mainstays in the introduction of the hydroxy-group into aromatic hydrocarbons by sulfonation and subsequent alkali-fusion. Beta naphthol, one of the most important intermediate products of the coal tar color industry has been produced during the last thirty years in enormous quantities by this method, which is prototype for the synthetic production of phenol. In Germany, synthetic phenol has been produced in insignificant quantities in the last decade of the last century, but when England, during the Boer rebellion, placed an embargo on phenol and a considerable shortage occurred on the continent, the chemical works of F. Raschig in Ludwigshafen engaged in the manufacture of phenol on a large scale and has maintained this whenever the price fluctuation of natural phenol permitted. The chemical works of Hoffmann-La Roche in Basle also produced synthetic phenol for many years and have always been able to compete successfully with the natural product for pharmaceutical purposes.

In this country, previous to the outbreak of the great war, synthetic phenol was never produced, however, not because of our inability, but for economical reasons. Thomas A. Edison, who was the first seriously to feel the consequence of the complete shut-off of the phenol

*A lecture delivered before the National Exhibition of Chemical Industries in New York City on Sept. 24, 1915.

supply, as he uses large quantities in the manufacture of his phonographic disk records, which contain the artificial resin prepared from phenol, as binder and are "faced" with a varnish of the same material, deserves credit for fearless and energetic action in quickly engaging in the manufacture of phenol from benzol. Already early last fall his plant in Silver Lake, N. J., produced synthetic phenol sufficient for his immediate needs, which are considerable. This most creditable achievement is only marred by the fact that the old and well known process was claimed as his own invention, and the appearance of exaggerated and foolish stories in the newspapers was permitted and countenanced.

With the arrival of demand for high explosives from Europe the demand for phenol increased enormously, and gradually other concerns began to prepare for the manufacture of phenol, and all of the many new organizations which were formed on the basis of often fictitious contracts for picric acid for the belligerent governments were compelled to consider the manufacture of phenol. While normally the price of synthetic phenol is about 9 cents per pound, with benzol at about 60 cents per gallon the cost price of synthetic phenol is about 18 cents. But when we consider that the price of picric acid is at present \$1.50 to \$1.75 for large contracts and that from one pound of phenol about $1\frac{3}{4}$ pounds of picric acid are obtained, we can see what enormous profits are theoretically involved.

The Manufacture of Synthetic Phenol From Benzol

The synthetic production of phenol from benzol comprises the following steps and operations:

1. Sulfonation of the benzol by strong sulfuric acid.
2. The conversion of the resulting mixture of sulfuric acid and benzol-sulfonic acid into the calcium salts by adding milk of lime to the diluted sulfonation mixture.
3. Separation of the soluble calcium salt of the benzol-sulfonic acid from the gypsum by filtration.
4. Conversion of the calcium salt of the benzol-sulfonic acid into the sodium salt (and separation of the solution of the latter from the precipitated calcium carbonate.)
5. Evaporation (to dryness) of the sodium salt of the benzol-sulfonic acid.
6. Caustic fusion of the sodium salt of the benzol-sulfonic acid.
7. Dissolving the fusion and acidulating the same to liberate the phenol formed and separating the same from the aqueous solution of the salts.
8. Distillation of the crude phenol.

(1) SULFONATION OF THE BENZOL

This operation is carried out in the customary sulfonation kettles, consisting of a cast iron kettle of perhaps 300-350 gal. capacity, having a jacket of any preferred material capable of being heated, either by water, steam or an oil circulating system, to about 80 deg. C. The kettle is in this case preferably provided with bottom discharge. The lid must close tightly, a soft lead casket having been found satisfactory. The lid is provided with man or hand-hole, thermometer pipe, 4-in. opening for running in the charge, an emergency opening, if desired, and connection to a spiral reflux condenser, water cooled, for condensing the benzol vapors. The kettles are elevated to permit gravity discharge into the limeing tanks.

The stirring device is of the greatest importance. Owing to the great difference of the specific gravities of sulfuric acid and benzol, the tendency to separate into two layers and rotate as such is very pronounced, and it is obvious that in that case chemical action is

very much impeded. The ordinary horeshoe type of agitator is therefore entirely unsuitable. Two types of agitators have been tried out, and both give about equal satisfaction. One type consists of a pair of ordinary propellers mounted on the shaft, one pair, however, being set conversely to the other; proper speed being 120-180 r.p.m. The other type consists of one complete turn of a broad spiral round the shaft, the whole revolving in a cylindrical case, which is either mounted on the shaft, rotating with same, or is stationary, viz., suspended from the lid or otherwise, a screw conveyor in fact.

For the production of one ton of phenol per day a battery of two kettles is necessary, each kettle being charged and operated twice.

In the cold or slightly warm kettle 410 lb. of sulfuric acid 98 per cent is run in, preferably from a measuring vessel common to all units of the battery. The agitator remains standing. One hundred and fifty-three pounds of benzol are next run in the kettle, the agitator still standing. The operator now closes all openings, excepting that leading to the reflux condenser, and starts the agitator. The temperature soon rises to 62-68 deg. or even higher.

When the thermometer indicates no further rise, heat is admitted to the jacket, and from now until the end of the operation the temperature is maintained as closely as possible to the boiling point of benzol; care, however, must be taken to prevent too energetic ebullition of the benzol which would otherwise be thrown through the condenser.

The sulfonation requires from 5 to 9 hours (in the mean, 7 hours) and is finished when the odor of benzol is practically gone (it never disappears completely) and a sample of the sulfonation, when diluted with many times its volume of water does not separate any drops of benzol. No benzol di-sulfonic acid is formed under these conditions, and the amount of sulfon is negligible. With benzol of good quality and at least partially freed from thiophene, the color of the sulfonation mixture is light straw yellow; on cooling, benzol-sulfonic acid separates in fair quantities, occasionally in crystalline form.

(2) CONVERSION INTO CALCIUM SALT

After completed sulfonation, the resulting mixture of sulfonic acid and sulfuric acid is run into about an equal volume of water contained in the limeing tank. The limeing tank may or may not contain a certain amount of milk of lime or calcium carbonate paste (from the soda tanks).

The limeing tanks (two being necessary for the quantities assumed above, but will suffice for a much larger production) are wooden tanks, preferably, but not absolutely necessarily, lead-lined, with powerful wooden agitators of the "gate" type, all iron parts protected and having a lead steam coil or an open steam pipe. The capacity of each is 1200 gal.; 4-in. bottom outlet, flanged and "flush" inside, proper draining being assured by a slight tilt. Bottom outlet connected to filter press pump (or Montejus if used, which is not advisable).

The milk of lime is prepared in a suitable vessel, for instance a sheet-iron cylindrical tank with iron stirrer and a perforated cage-like basket, removable, in which the lime is placed. Suitable capacity 500 to 600 gal. A straining device should be attached to the outlet.

Suitable proportions for the milk of lime: 1 lb. of burned lime for 0.6-0.75 gal. of water.

The operation of limeing is carried out as follows: Milk of lime is run into the diluted sulfonation mixture, the latter being hot due to the hydration heat of the acid. Steam is turned into the coil when the milk

of lime begins to run in. The milk of lime is added just short of the point of alkalinity, viz., until all sulfuric acid and the largest part of sulfonic acid is neutralized; then sufficient calcium carbonate (chalk or from the soda tanks) is added to neutralize completely. The content has now begun to boil and is maintained boiling for about 20 to 30 min. If it should become too thick, a little water may be added. (Very little water is necessary to thin the mass.) The steam is then turned off and cold water equal to about $1\frac{1}{2}$ volumes of the original volume of the sulfonation mixture is run in.

All these precautions serve the purpose of obtaining the gypsum precipitate in a form permitting rapid filtration and complete washing out of the press cakes with the least volume of water.

(3) SEPARATION OF SOLUBLE CALCIUM SALT FROM GYPSUM

Two filter presses are desirable, but one may do. The filter press with washing device made by Shriver & Co., Harrison, N. J., is probably the best, but when ordering, it should be insisted that two washing inlets, one at the bottom and one at the top of the plate are provided (which is done without extra charge). Open discharge! The lower washing holes should be worked first. Filter presses are best raised on a platform high enough to permit a dumping cart to be driven under it, into which the gypsum cakes are dropped through a chute.

The contents of the limeing tube are pumped into the press at a temperature of about 60 deg. C. and the filtrate collected in the soda tubs. The cakes are washed, by means of the washing attachments, with hot water, the first washing being added to the filtrate while the last wash water may be turned back into the limeing tub in place of pure water for diluting the sulfonation mixture. The amount of wash water necessary depends largely upon the state and form of the gypsum precipitate, that is, if the same has been properly prepared and treated, comparatively little washing will be required, while, on the other hand, if it has been allowed to become slimy, it is very difficult to completely remove the calcium benzol sulfonate from it. The economy of the process depends to a large extent on this factor. Generally speaking the volume of the solution should not be increased more than 50 per cent by the washing operation.

(4) CONVERSION OF CALCIUM SALT INTO SODIUM SALT

The filtrate and wash waters are run by gravity from the troughs of the filter presses into a wooden tub. Two are advisable, of a capacity of 1500 gal. They need not have a stirring device, but preferably have a light one, or may be agitated by air or even by hand. They may have a closed steam coil of good size, in order to evaporate while filling and to boil, which is necessary in order to obtain the calcium carbonate in the proper crystalline form. Soda ash (dry) is added until all calcium is precipitated, which point is recognized when further addition fails to produce more precipitate and by the slight alkaline reaction. No excess of soda should be allowed.

The calcium carbonate is allowed to settle, and the supernatant clear liquid is fed to the evaporator. After the layer of calcium carbonate has increased, say after three or four conversions, it is washed once with water and then withdrawn and used for neutralizing the sulfonation mixture.

(5) EVAPORATION

Evaporation of the sodium salt is obviously carried out most economically in a multiple-effect vacuum evaporator and the drying of the salt in a vacuum oven.

However, the temporary nature of the proposition does not always warrant the large investment for installing this apparatus, and any means for evaporation and drying, such as tanks with steam coils for concentration and jacketed shallow pans for drying may be employed.

The dry sodium salt represents a dazzling white finely crystalline mass, which, for the fusion, should be pulverized to a coarse powder, any means to that end being suitable.

The yield of the sodium salt should be practically theoretical, any losses being mechanical and most probably due to incomplete washing of the gypsum cakes.

(6) CAUSTIC FUSION OF THE SODIUM SALT

The caustic fusion is carried out in open cast-iron round-bottom kettles, of about 300 gal. capacity, having an iron stirrer of the horseshoe type, which should as closely as possible approach the sides and bottom of the kettle.

Two fusion kettles are preferably set in brick, arch construction or sheet steel protector to prevent direct contact with the flame.

Heating means, preferably: Schutte & Koerting (Philadelphia) gravity oil burner, size $\frac{1}{4}$ in.

The kettle is charged with 480 lb. of caustic soda and 30 to 50 lb. water added, which facilitates the melting of the soda. The temperature is raised to 270 deg. C., and then 600 lb. of dry pulverized sodium salt of the benzol sulfonic acid are shoveled in. The temperature should not be permitted to fall, but should, during the throwing in of the sodium salt, rise, so that when all of the latter is in, about 300 deg. C. has been reached. This can be readily done by increasing the flow of the oil of the burner and by regulating the speed with which the salt is added. When all has been added the temperature of the fusion is raised to about 315 deg., whereupon the heat is turned off. The temperature rises a little further but should never exceed 330 deg. However, observation of the temperature is not very essential, as with a little practice the progress, etc., of the fusion can readily be observed and followed by the appearance of the same. A description of these visual indications, however, would help but little, and experience and a few trials in the laboratory will quickly enable the supervising chemist to determine the correct conditions. In general the fusion is completed, when all sodium salt has gone into solution, and the melt becomes thin. No separation in two layers takes place with the above proportions.

(7) DISSOLVING THE FUSION AND ACIDULATION WITH LIBERATION OF PHENOL

When still hot and liquid, the melt is ladled in shallow iron pans or trays and broken up after having solidified and cooled. A crusher might suitably be employed. The workmen must be provided with rubber gloves and goggles and should be advised to protect their clothing with pieces of sacking. Clogs or wooden shoes, such as worn by the Lancashire mill hands, are also recommended.

The broken-up fusion cakes are now dissolved in water, two parts of water to one part of fusion. The best apparatus for this operation is a sheet-iron cylindrical tank with conical bottom, similar to a benzol washer; it need not be lead-lined as, in contradistinction to the separation of tar-phenol from the alkaline solution by mineral acids, no danger of over-acidulation exists, as acid is only added until bisulphite has been formed. The tank may be open, but should be provided with a hood.

A perforated false bottom, preferably arranged that it can be lowered and raised and entirely removed, should be provided in the tank, and agitation is prob-

ably best provided by air. A lead-pipe with perforated coil, a little above the conical end, serves for running in the acid, and the usual arrangement for withdrawing the liquid at the bottom and at different levels should be provided.

When the cakes are dissolved diluted sulfuric acid from a lead-lined storage vessel is run in until the beginning of copious evolution of sulfurous acid indicates the beginning of the decomposition of the bisulphite. Five thousand pounds of cakes require about 2500 lbs. of sulfuric acid 100 per cent in form of 40 deg. Be. The contents of the tank are now allowed to stand, the aqueous solution containing sodium sulphate and sodium bisulphite is subsequently withdrawn at the bottom, and the phenol freed from sulfurous acid by vigorously blowing air through it for some time.

(8) DISTILLATION OF CRUDE PHENOL

The resulting crude phenol is now distilled from a phenol still and gives, after removal of the forerun, pure crystalline phenol of the highest melting point.

The yield obtained should be one pound of phenol for one pound of benzol.

The synthetic phenol thus prepared possesses frequently a very disagreeable odor characteristic to organic sulfur compounds. Whether this odor is due to the presence of thiophene in the benzol or to compounds formed by the reducing action of the iron in the fusion kettle (or possibly sulfonation kettles) on the sulfuric acid or sulfites, the writer expresses no opinion. This odor, however, can be readily and completely removed by digesting the crude or distilled phenol with common wood charcoal or still better animal charcoal, or distilling it over the same.

Traces of diphenol (dioxy-diphenyl) appear in the after run.

As in all similar cases, when an old established method suddenly obtains greater importance than was the case before, inventors, real and otherwise, have become active. In the case of phenol no tangible result has been obtained. All methods suggested as "short-cuts" in the sulphonation and fusion phases of the process have proven futile. Of course, modifications of the different steps are always possible. So it is, for instance, possible to sulfonate benzol with fuming sulfuric acid of various anhydride contents, but it is then necessary to keep the temperature of the reacting mixture well below 50 deg. as otherwise considerable amounts of disulfonic acids are formed increasing, of course, with the concentration of the anhydride.

Another "invention" often submitted by would-be "phenol experts" is the direct production of the sodium salt of the benzol sulfonic acid by treating the sulfonate with solutions of common salt. This "invention" is based on the practice followed by certain beta naphthol manufacturers, but is unrational because of mechanical difficulties occasioned by the necessity of filtering strongly acid solutions. Furthermore, the "salt" thus obtained contains large amounts of glauher salt, which are a nuisance in the subsequent fusion and require the use of larger proportions of caustic soda. The suggestion centering in directly neutralizing the sulfation and digesting the mess with caustic is too ridiculous to be considered seriously, and only demonstrates the deplorable ignorance in such matters of those who advance it.

Chlorbenzol is a fairly readily accessible, cheap material, especially if use is made in its manufacture of the chlorine produced by the electrolytic alkali manufacture. The chlorine atom in aromatic compounds can be replaced more or less readily by the hydroxy-group by digesting the chlorinated compound with alkalis.

When more substituents are contained in the kernel, especially negative ones, the chlorine atom can be replaced very readily, but chlorbenzol is very inert as regard to this reaction and very high temperature and dilute solutions of caustic soda are necessary to perform satisfactorily this conversion. For this reason, which necessitates the use of autoclaves for very high pressure and large volume, the industrial application of this elegant short method for preparing synthetic phenol is out of question.

The Manufacture of Picric Acid

Picric acid is the tri-nitro derivative of phenol, the product of an exhaustive nitration of phenol, many of its derivatives and to some extent of many organic substances.

It presents pale yellow crystalline leaflets of exceedingly acid taste soluble to about 1 per cent in cold water, more readily in hot water, easily in ether, alcohol and the usual organic solvents. F. P. 122.5. Ignited it burns, without explosion; detonated by fulminates (Ag or Hg) or guncotton it explodes and is one of the brisantest explosives. The salts are very explosive and also a detonator for free picric acid. Specific gravity of fused picric acid is 1.64.

The technical production of picric acid is to-day carried out by two distinct processes:

1. The first and oldest method, which even to-day is employed almost exclusively, consists in nitrating the phenol sulfonic acid obtained by treating phenol with concentrated H_2SO_4 at about 100 to 110 deg. until the odor of phenol has disappeared and the reaction product is completely soluble in water, with an excess of nitric acid, preferably in the presence of an excess of sulfuric acid.

2. The second and more modern method employs as starting material chlorbenzol, which is dinitrated to dinitro-chlorbenzol; this product is separated from the spent nitrating mixture, the chlorine atom replaced by the hydroxyl by heating with caustic soda, and the resulting dinitro-phenol is nitrated.

The possibility of a third commercial method for the production of picric acid is suggested by an old publication by Hepp, *Ann.*, 215, 344 (1882), who claims to have obtained, with an excellent yield, picric acid by oxydizing trinitrobenzol in alkaline solution with potassium ferric cyanide, the possibility of the use of other mild oxydizing agents being implied.

In view of the difficulty in obtaining trinitrobenzol with anything like a satisfactory yield, the commercial feasibility of such procedure, is open to grave doubt, although the writer has private information that a small plant is at the present time producing picric acid to some extent by a process purported to be based upon this method, literature on trinitrobenzol, Kekule, *Ann.* 137, 167; Salkowski, *Rehs, Ber.*, 7, 371; Hepp, *Ann.*, 165, 18.

The chemical and technical literature contains many suggestions and several descriptions for the manufacture of picric acid, all of them, however, being obsolete. Chemically, the preparation of picric acid is very simple and easy and, as a matter of fact, it would seem almost impossible for anyone placing phenol and nitric acid together, in some form and manner, not to obtain picric acid. Technically, however, the manufacture involves several difficult problems, mainly due to the fact that the handling of straight nitric acid is a difficult and dangerous operation precluding the use of materials for receptacles, etc., usually employed in the chemical industry and the somewhat exaggerated fear of contaminating by inorganic salts, detrimental to the stability of the product. The drying and pulverizing of

the material is a very dangerous operation, which, however, is now seldom required in chemical factories, the ordnance works usually requiring delivery of the wet crystals with a moisture content of approximately 20 per cent.

The manufacture of picric acid is carried out as follows:

A large sulfonation kettle of the usual construction, preferably lead-lined, with steam jacket, bottom discharge and agitator, is charged with one part phenol and four parts sulfuric acid, 98 per cent. The mixture is heated under agitation until a sample appears completely sulfonated, that is, soluble in H_2O without turbidity and the complete disappearance of the phenol odor. The content of the sulfonation kettle is now divided into the nitrators which are receptacles, suspended in a space adapted to have hot or cold water circulated therein. To the content of each kettle an equal part of sulfuric acid is added, and after reducing the temperature to below 20 deg. the nitrating acid is run in. The nitrating acid is preferably the usual mixture of equal parts of HNO_3 (40 deg.) and H_2SO_4 , but any other proportion is equally suitable. Instead of three molecules required by the theory, four molecules of HNO_3 are added, the temperature being kept below 40 deg., while the first 30 to 40 per cent nitric acid is run in and then gradually increased to 70 or 80 deg., hot water being circulated toward the end of the operation and one to two hours afterward. Proper ventilation must be provided. Air may be blown through the nitrators before removing their content in order to remove the nitrous gases formed.

The content is now removed into an acid-proof, non-metallic receptacle and diluted with water, about equal volumes having been found to give the best results. After cooling, the picric acid, which separates usually in large crystals, is placed on filtering means, "nutches"

or centrifuges, and washed. The formation of too large crystals and "caking" should be prevented. It is usually of sufficient purity for any requirements. To obtain it still purer it may be fused in steam-jacketed enamelled kettle, from which it is run, if desired, through a sieve of platinum or gold, into a wooden tank with water. It is then filtered again. The method suggested in the literature of dissolving in alkali and again precipitating is unrational and dangerous and has never been practised by manufacturers.

The material from which the nitrators are made may be cast-iron, if the strength of the acid is always kept above 82-85 per cent, otherwise earthenware or enamel receptacles are indispensable. After the nitration the mixture is diluted, and for all final operations, contact with metals, other than precious, must be avoided. Coatings of a pure asphaltum varnish have given satisfaction. Proper agitation devices and ready means for discharging the nitrators and filling the same open a wide field for the ingenuity of the construction engineer.

The largest manufacturers of picric acid in the world (Hauff in Fuerbach) use an interesting and highly efficient filtering device. It consists of a filtering box or "nutch," with vacuum below and above, and is adapted to be used as both filter and dryer. The crude picric acid is placed on the filtering surface (a porous stone plate) and suction is applied. After the bulk of the adhering waste acid has been removed, alcohol is sprayed on the material and received in a separate container, from which it is at once rectified and recovered. The filter box is then covered with a specially constructed lid and vacuum applied; the drying proceeds very rapidly and the resulting product is very pure, due to the fact that it has been washed with alcohol, which is an excellent solvent for the resinous products, always formed during high nitration.

First National Exposition of Chemical Industries

The National Exposition of Chemical Industries held in the Grand Central Palace, New York, from Monday to Saturday, Sept. 20 to 25, 1915, was a real great success, even greater than its promoters and most sanguine well-wishers could have hoped for. Like every exposition, it was a little slow in starting, but by Monday night all the exhibits were well in place, and it was then evident that in spite of being the first exposition of its kind held in the country it was a surprisingly finished and thoroughly representative affair. It is true manufacturers in a few fields, such as chemical stone-ware, were absent, but these were exceptions which only emphasized still more the fact that otherwise the exhibition was truly representative of the industry. The exposition is planned as an annual affair, and the surprising success of the first trial promises even greater successes for the future.

The idea of this exposition originated with two American chemists, Mr. Adrian Nagelvoort and Mr. Charles F. Roth, to whom a great deal of credit is due not only for the origination of the idea but for the perseverance, energy and good common sense with which they made a reality of their idea. They formed an advisory committee, consisting of Messrs. Raymond F. Bacon, H. B. Faber, Charles H. Herty, Arthur D. Little, Wm. Cooper Proctor, E. F. Roeber, George D. Rosengarten, T. B. Wagner and Utley Wedge. Associated with Messrs. Roth and Nagelvoort in the management of the exposition was the International Exposition Com-

pany, with Mr. F. W. Payne at the head, whose experience gained in the past in managing fifty large expositions contributed greatly to the success of the present exposition and to the satisfaction of every exhibitor.

The attendance was excellent and high-class in that chemical engineers, managers and superintendents, in general, men with buying power, were present, many of them from out-of-town places and from quite distant states. In honor of the visiting chemists the Chemists' Club held a smoker on Thursday night with vaudeville entertainment; it was a well attended and greatly enjoyed affair.

The general public was also greatly attracted by the exposition; on most of the evenings the show was quite crowded. The average daily attendance was quite a little over 10,000. It may thus be hoped that the exposition has promoted a better understanding by the general public as to what the chemical industries are and stand for. Certainly never before in the history of the world have the New York daily papers shown as much interest in chemistry as during the exposition week.

The adjoining illustrations will give an idea of the attractiveness and comprehensiveness of the exhibition; more details will be found in the concise summary of the different exhibits. We will finally give a review of the numerous meetings and lectures held in connection with the exposition—some of the papers presented are given in the present issue, while more had to be reserved for publication in later issues.

Finally great credit is due to the Bureau of Commercial Economics of Washington, D. C., which had arranged a very interesting moving-picture program on many chemical, metallurgical and industrial subjects, the films varying from day to day.

A concise summary of the exhibits arranged in alphabetical order of the names of the exhibiting companies follows:

Abbe Engineering Co., New York City, exhibited small jar or ball mills in actual operation and also showed a small size of their improved "Max" mill which has a vertical shaft, designed to reduce vibration. Mr. Henry Kleinfeld was in charge.

American Bitumastic Enamels Company, New York City, showed diagrams of the lock gates of the Panama Canal which were treated with their enamel after two years' test with various materials. The enamel has an asphalt base. Messrs. Sealey, Kerns and Ellis were in charge.

American Chemical Society exhibited publications and charts showing the growth in membership during the last few years. Also booth for entertainment of visitors.

American Electrochemical Society:—Pictures of pioneers in electrochemistry and electrometallurgy and also a large portrait of Robert Hare. Historic electric lamp exhibits, an exhibit showing the development of the tungsten lamp; argon-filled lamps, Cooper-Hewitt lamps. Various fine samples of electrochemical products from Niagara Falls. This was undoubtedly the most interesting Society booth at the show. Dr. Doremus, Mr. Bowman and Mr. Muir were responsible for the exhibit.

American Hard Rubber Company, New York:—Acid pumps, buckets, bottles, piping and various other utensils all made of hard rubber. Messrs. F. R. Greuse and E. Johnson were in charge.

American Institute of Chemical Engineers had a booth for entertainment of visitors.

American Paper and Pulp Association, New York City, showed photographs of woods and pulps made from them. This exhibit was loaned by Joseph H. Wallace & Co. of New York.

American Transformer Company, Newark, N. J., had an exhibit in conjunction with that of the Research Corporation, they having supplied the 100,000-volt transformer for the demonstration of the Cottrell electrical precipitation process. Mr. W. F. Hubley was in charge.

Ault & Wiborg, Cincinnati, Ohio, manufacturers of printing ink.

Automatic Weighing Machine Company, Newark, N. J., showed very instructive photographs of their automatic weighing and sealing machines. Messrs. H. D. Bowman and J. B. Mockridge were in charge.

J. T. Baker Chemical Company, Phillipsburg, N. J., had an attractive exhibit of Baker's analyzed chemicals neatly arranged in show cases.

Beach-Russ Company, New York City:—Small sizes of their rotary vacuum pumps and pressure blowers in operation. Their compound dry vacuum pump is guaranteed to produce a vacuum within 1/10 in. of barometer. Messrs. H. C. Russ and J. Buckley were in charge.

Christian Becker, Inc., New York City:—Exhibition of analytical balances. The feature of this exhibit was their new chain balance which weighs without weights, by having a gold chain fastened to the lever arm, the other end of which is raised or lowered to give different weights which are read on a scale, provided with vernier. Readings are accurate to 1/10 of a milligram. Messrs. C. G. Machilas and W. C. Symington were in charge.

W. Beckers Aniline and Chemical Works, Brooklyn, N. Y.:—A very neat exhibit of American made aniline and alizarine colors. The exhibit showed coal as a raw product, then the intermediate products, and finally the finished colors and the dyeing solutions. Messrs. Gustav Drobegg and Cillessen were in charge.

Benzol Products Company, New York City:—An interesting exhibit of coal tar products, including benzol, nitrobenzol, aniline oil, aniline salt, and oxide of iron as a by-product. Mr. J. R. de la Torre Bueno was in charge.

Bethlehem Foundry & Machine Company, Bethlehem Pa.:—A fine tantiron exhibit. A comparative corrosion test was in process with nitric acid dropping on a small piece of "tantiron" and then on ordinary cast iron. A new piece of ordinary cast iron was used each day and the same piece of tantiron was used all the time. The superiority of tantiron with respect to resistivity to corrosion was evident. Messrs. Lehman, Wilbur, A. H. Stevens and Ettle were in charge.

Brown Instrument Co., Philadelphia, Pa., exhibited their electric pyrometers, stationary and portable, also record-

ing electric pyrometers. Messrs. Goheen, Andrews and Printz were in charge.

Buffalo Foundry & Machine Company, Buffalo, N. Y.:—This was one of the most attractive exhibits and occupied the whole back wall of the Exposition Hall. Numerous colored plates, lit up from the inside, showed various castings made by this concern. These were on the rail surrounding the booth. In the booth were many large castings, including a large reducer for aniline work, a caustic pot, crystallizing pan, condenser and cooler bodies for nitric acid, vacuum dryer and vacuum shelf dryer, and dry vacuum pump for pumping within 1/20 in. of barometer. A test was conducted showing the insolubility of "Buflokast" iron in various hot acids, compared with the solubility of common iron. Great surprise was shown by many people at the very large and varied line of work in chemical industries, as illustrated by this exhibit. Messrs. H. D. Miles, E. G. Rippel, E. G. Sleeper and H. B. Underwood were in charge.

Celluloid Zapon Co., New York City:—Lacquer enamels and lacquer, nitro-cellulose and a complete display of different materials treated by "Zapon." Mr. N. E. Dabolt was in charge.

Chemical Catalog Company, New York, N. Y., showed a dummy illustrating the nature of their catalog of chemical apparatus which will appear about the middle of 1916. Mr. R. R. Johnston was in charge.

The Chemists Club, New York City, had on exhibit a series of old photographs and prints of famous chemists, which attracted considerable attention.

Cinnakol Chemical Sales, Bayonne, N. J.:—Samples of their Cinnakol disinfectant, which is non-poisonous and soluble in water.

Detroit Range Boiler Co., Detroit, Mich.:—The Perfect metal bilge barrels on exhibit by this company attracted considerable attention as they have removable heads which can be made liquid tight to conform to I. C. E. specifications. They also exhibited 110-gal. drums which they made for customers who could not get them from Europe. Mr. W. B. Goddard was in charge.

J. P. Devine & Company, Buffalo, N. Y., exhibited one of their vacuum pumps and other apparatus and machinery of their design for the chemical industries. Also a very interesting exhibit showing the quantities of raw material required to produce one pound of phenol crystals from pure benzol in a process installed by them on a large scale. Messrs. F. H. Mason, Charles Devine and R. D. Kehoe were in charge of the exhibit.

Dorr Cyanide Machinery Company, Denver, Col.:—Very instructive working models of the Dorr classifier, agitator and thickener; also a complete working model of their recent continuous causticizing apparatus in which demonstrations were given of the manufacture of caustic soda from soda ash and lime, applying the principle of continuous counter-current decantation (see our issue of August, 1915 p. 514). Messrs. J. V. N. Dorr, Noel Cunningham, H. N. Spicer, R. W. Shafor and L. B. Donaldson were in charge.

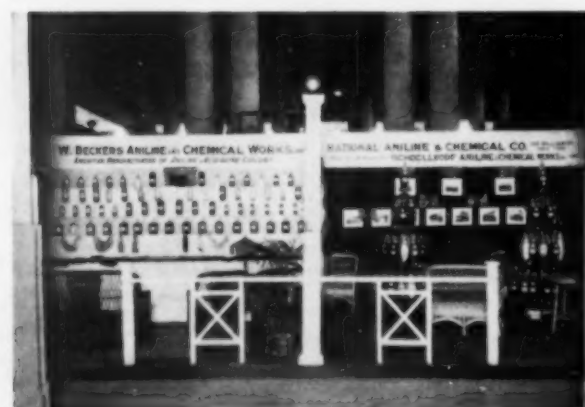
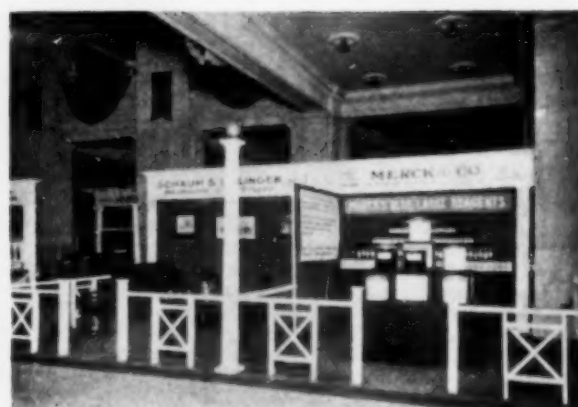
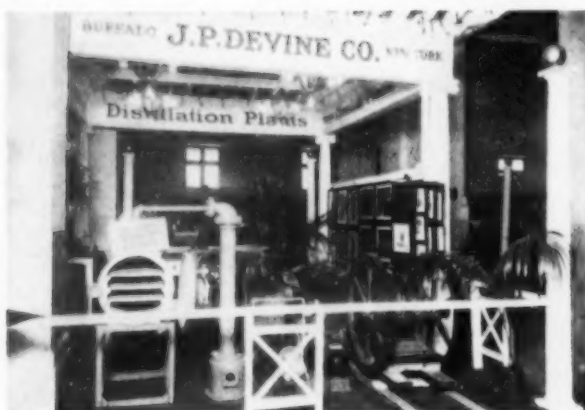
Driver-Harris Wire Company, Harrison, N. J., showed tests on their "nichrome" resistor wire, passing an electric current through of sufficient strength to heat the wire to bright redness in open air, the wire retaining its stability. They also had on exhibit a basket which had been immersed in fused potassium cyanide for eight months (steel hardening process), remaining unaffected. Messrs. Tracy, Bensel, Hart and Henderson were in charge.

DuPont Chemical Company, New York City (owned by Dupont Powder Co.) showed samples of their various products, among which were benzol, pyroxylin or soluble cotton, commercial amyl acetate. Their various split leather solutions were shown by samples of rough split leather. An exhibit of Fabrikoid was also included. Mr. R. L. Vilas was in charge.

Duriron Castings Company, New York City, exhibited nitric and sulphuric acid condensers; a sulphuric acid concentrator for making 66 deg. Be acid from chamber acid; solid "Duriron" valves and a new 4-in. x 8-in. acid pump used largely for filter press work. Messrs. J. R. Pitman, I. D. Horton and P. D. Schenk were in charge.

Thomas A. Edison, Orange, N. J.:—Benzol, toluol, xylol, and numerous other products. A motor truck size of his new alkaline battery showing the nickel flake, nickel hydroxide, and iron oxide attracted considerable attention. Mr. W. Mallory was in charge.

Eimer & Amend, New York City, exhibited a great many of their laboratory supplies, among which were the Barnstead automatic water still, hydraulic hardness testing machine; "Eanda" American flasks and beakers, and porcelain ware and the Fleming absorption tube. A source of particular interest was found in the new "High-Temp" electric



Exhibits at First National Exposition of Chemical Industries

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furnace manufactured by the Electric Heating Apparatus Co., which was in actual operation. Mr. E. Child was in charge of the booth and Mr. Smalley demonstrated the furnace.

Elyria Enamelled Products Co., Elyria, Ohio, exhibited four enamelled kettles, illustrative of their line of seamless, one-piece, acid and alkali resistant chemical apparatus. Messrs. William E. Gray, vice-president, J. O. K. White, and E. P. Poste were in charge.

Charles Engelhard, New York City, exhibited the Heraeus Le Chatelier pyrometers for temperature measurements up to 1600 deg. C. This exhibit was in conjunction with the Hanovia Chemical Co. of Newark, N. J. Mr. R. A. Newcomb was in charge.

Fairview Fluorspar & Lead Co., Golconda, Ill., exhibited large blocks of fluorspar, lead ore (galena) and gravel and ground fluorspar.

Foote Mineral Company, Philadelphia, Pa.:—Exhibit of unusual ores, including zirconia ore. Refractory bricks, pure zirconia oxide, silicate, zirkite cement, all made from zirconia ore formed an important part of their display. Mr. H. C. Meyer was in charge.

Geissinger Regulator Company, New York City:—Demonstration of the Geissinger industrial temperature-control system for all classes of temperature-control work, such as conveyor type ovens, large flue dampers in superheaters, dryers, etc. This exhibit was in connection with that of Gerdes & Co.

General Bakelite Company, New York City:—Various products made from this material, showing its wide range of applicability. Included in this exhibit were Weston galvanometers, general molded insulation apparatus, high tension molding for automobile work, some beautiful parasol handles, and cane handles, fountain pens and billiard balls which are more elastic and less resistant to damp weather than ivory. The exhibit was in charge of Mr. H. S. May.

General Chemical Co., New York:—Demonstrations of the baking qualities of their new baking powder "Ryzon," which they have recently placed on the market. Mrs. E. J. Martin was in charge.

Gerdes & Company, New York City, showed their hygienic ventilating apparatus, gears, castings and the Hopes pyramid grate, for improved fuel economy in both natural and forced draft. Mr. Theodore R. N. Gerdes was in charge.

Glens Falls Machine Works, Glens Falls, N. Y., exhibited the Tromblee & Paull rotary sulphur burner, of which they are sole manufacturers. Mr. Hall was in charge of the exhibit.

Emil Greiner Company, New York City, exhibited glassware and miscellaneous laboratory supplies. A feature of their exhibit which attracted attention was a "day-light arc lamp." A filtering glass is placed below a concealed source of light so that the different colors pass through in the correct proportion of daylight spectrum; for color and paint plants, dyeing works and in general for purposes where exact color matching is important.

Hanovia Chemical Co., Newark, N. J.:—Showed Heraeus quartz glass, long distance thermometers, Heraeus pure platinum laboratory furnaces, for temperatures up to 1400 deg. C. and Heraeus transparent quartz glass chemical apparatus. Mr. S. W. Robinson was in charge.

Hardinge Conical Mill Company, New York City:—Complete working model of the Hardinge Mill with glass arranged so that the inside working could be seen. This is a continuous feed and discharge grinding machine. Mr. R. Clark was in charge.

Heller & Merz Company, Newark, N. J.:—Aniline colors, also Bleachette laundry blue and Alderney butter color. Mr. W. J. Robertson was in charge.

Huff Electrostatic Separator Co., Boston, Mass.:—Small working model of the Huff separator which uses 12 to 28,000 volts on ore separation, and a small model of the Plumb pneumatic jig for ore separation. These are both dry processes. Mr. H. P. Johnson was in charge.

F. C. Huyck & Sons, Albany, N. Y.:—Samples of their woven woolen filter cloths. Mr. J. C. Standish was in charge.

International Filtration Corporation, New York City, showed a rotary continuous vacuum filter and their movable leaf or cell type vacuum filter. This consisted of three tanks with an overhead travelling set of filter plates provided with suction. This set of plates could be transferred from one tank to the other for washing after forming the cake in the first tank. Messrs. Dickey, Wheat, Faber and Crosby were in charge.

International Instrument Company, Cambridge, Mass.:—Shaking machine for small bottles, and a complete laboratory centrifugal on exhibit. Mr. Arthur Kendrick was in charge.

Kieselguhr Company of America of Los Angeles and New York City, showed their "sil-o-cel" bricks, and powder made of pulverized celite, and gave a demonstration of the heat withstanding qualities by applying a blast lamp directly to a "sil-o-cel" brick. Messrs. D. S. Collins and P. A. Boeck were in charge.

Lead-Lined Iron Pipe Company, Wakefield, Mass., exhibited valves and pipe fittings, all lead-lined; a feature of their exhibit was a sample piece of 16-in. lead-lined iron pipe furnished by the Chile Copper Company, Antofagasta. Mr. T. H. DuBois was in charge.

Lenz & Naumann, New York City:—General laboratory supplies, including the Riché adiabatic calorimeter, Link's patented water purifier. Tirrell gas making machine for making gas from kerosene, Lenzmann micrometer, Bavarian porcelain ware (imported) of which they still have a supply. Dr. Lenz and Messrs. Naumann, Greenberg and Karstenhaus were in charge.

Emil E. Lungwitz, New York, exhibited the Kelly filter press in conjunction with L. O. Koven & Brother. This was a regular size press of which all the features could be examined. Dr. Lungwitz was in charge.

Macbeth-Evans Glass Company, Pittsburgh, Pa., showed chemical glassware made in U. S. A. to take the place of Jena ware. This included all sizes and shapes of beakers and flasks. Messrs. George D. Macbeth and F. S. Irving were in charge.

Merck & Company, New York City, exhibited a shelf of their well-known "blue label" reagents and large jars of hydro-quinone (manufacture in the United States begun in 1914), synthetic carboic acid, pure benzol, aniline oil and other products.

Metallurgical and Chemical Engineering placed its booth at the disposal of visitors and exhibitors with respect to telephonic, clerical and stenographic service. Mr. Burns was in charge. Messrs. Muir, Bedell, Munn, Bergen, Cain and Hays were in attendance.

The Mogul Company, New York; exhibit of their liquid for treating miscellaneous materials to render them acid and waterproof; also of materials treated by their products. Messrs. A. Gottlieb and C. H. Klepper were in charge of the booth.

Monsanto Chemical Works, St. Louis, Mo.:—Samples of acetphenetidin, caffeine, chloral hydrate, coumarin, phenolphthalein, saccharin and vanillin. Mr. B. M. Couvalt was in charge.

J. L. Mott Iron Works, New York City, showed cast-iron steam-jacketed porcelain-lined mixer and other acid resisting kettles of different kinds. Mr. R. H. Horne was in charge.

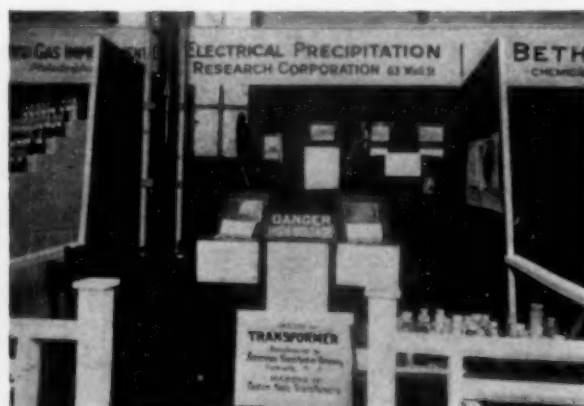
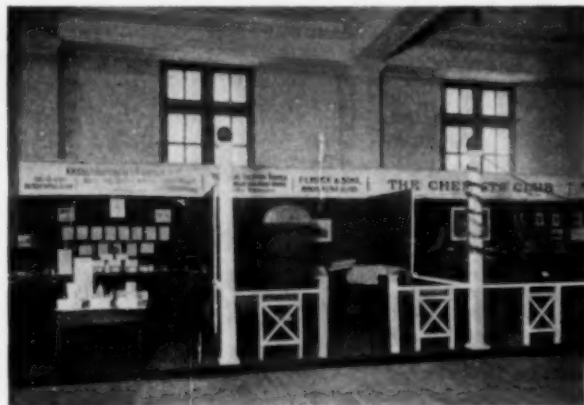
National Aniline & Chemical Company, New York City (selling agents for Schoellkopf Aniline & Chemical Company, Buffalo, N. Y.), had a fine exhibit of aniline colors and intermediate products, of which they have been the oldest American manufacturers. Mr. Henry Metz was in charge. Mr. I. F. Stone, president of the company, presented an admirable paper on Wednesday night on the aniline dye situation, which is printed in full elsewhere in this issue.

Norton Company, Worcester, Mass.:—Exhibit of alundum crucibles, tubes for carbon determination and various other refractory apparatus of alundum. A demonstration was made of the porosity of alundum by constantly dropping a liquid through a crucible of this material. Grinding materials were also shown. The columns at the corners of the booth were built up of grinding wheels. The booth was in charge of Mr. M. A. Williamson.

Pfautler Co., Rochester, N. Y.:—Exhibited an upright open tank, and an upright open jacketed tank lined with their acid proof enamel. These were small tanks but the construction was on the same basis as many of their larger tanks. Messrs. F. L. Craddock and N. G. Williams were in charge.

Raritan Copper Works, Perth Amboy, N. J.:—Exhibited ingots and wire bars of refined copper; also nickel sulphate and copper sulphate recovered. Their exhibit of selenium and tellurium, which are by-products, deserves especial mention. Selenium was exhibited in several different forms, namely, viz: red amorphous as powder, vitreous form as powder, sticks and half-pound cakes. Tellurium was in sticks and cakes. Besides this there were gold, silver, platinum and palladium. Messrs. S. Skowronski and C. H. Aldrich were in charge.

The Research Corporation, New York City, showed a small working model of the Cottrell electrical precipitation process for removing dust from gases. Frequent demonstrations were given and attracted a great deal of attention. The voltage used was about 40,000, whereas in actual practice up to 100,000 volts are used. The transformer was furnished by the American Transformer Co., Newark, N. J.



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Mr. Linn Bradley of the Research Corporation and Mr. W. F. Hubley of the American Transformer Co. were in charge.

Schaeffer & Budenberg Company, Brooklyn, N. Y., exhibited recording gages and thermometers of their Columbia and Crescent brands; also steam calorimeters, engine indicators, and stationary and hand tachometers. Their recording apparatus was demonstrated by a complete testing outfit. Messrs. Wimmers and Undertsch were in charge of the booth. Great credit for the attractive arrangement of it is due to Mr. Carlier.

Schaum & Uhlinger, Philadelphia Pa., exhibited the parts of a small centrifugal; also a small undriven basket type centrifugal together with photographs of their various designs. Messrs. C. W. Schaum and Leslie Griscom were in charge.

Schutte & Koerting Company, Philadelphia, Pa., had a complete working installation of the Bihn-Jones automatic air-lift except that the lift was not so high as would be encountered in practice. They also exhibited the Auld reducing valve for steam and air reduction, lead-lined valves and ejectors and various other engineering specialties. Dr. E. Kimberly was in charge.

E. Scott & Co., Fall River, Mass., showed photographs and blue prints of plants and machinery designed and installed by them, especially vacuum and distillation plants. Messrs. H. Austin and A. B. Kennedy were in charge.

Sharples Specialty Co., West Chester, Pa., showed their smallest and largest types of centrifugals. Principal interest in these machines is their high speed, the small one travelling at 20,000 r.p.m. and the large one at 40,000 r.p.m. They are hung from balls and are free at the bottom.

Sowers Manufacturing Co., Buffalo, N. Y., showed two standard type "Dopp" seamless kettles and a small experimental vacuum kettle. Messrs. C. M. DeForest, W. Bowman, and P. Cox were in charge.

Stamford Manufacturing Co., New York City, showed furs, silks, buttons, wool, cotton and leathers dyed with their vegetable dyes. The logwood produces the blacks and blues, the fustic produces the yellows and browns, the hypernic produces the reds, and these are further mixed to produce other shades. Mr. C. L. Young was in charge.

Sweetland Filter Press Co., New York:—The demonstrations of this filter press attracted very considerable attention as a complete small working filter was in operation with the necessary solutions, etc., for a complete demonstration. The metallic filter cloth used in conjunction with the press was also a source of much interest. Messrs. A. W. Wright and Howard Runyon were in charge.

Swenson Evaporator Company, Chicago, Ill., exhibited two of their standard evaporators, one the standard horizontal tube evaporator of the submerged tube type, the other the patented basket type, vertical tube "Seco" evaporator having 250 sq. ft. of heating surface by passing the liquid up through vertical tubes surrounded by steam in the basket, the vapor emerging at the top of the tubes. Messrs. F. M. De Beers and P. B. Sadler were in charge.

Tennessee Power Company, Chattanooga, Tenn., exhibited photographs and maps showing their completed and proposed hydro-electric developments on the Ocoee and Tennessee rivers. Messrs. E. A. Hitchcock and C. F. Long were in charge.

Thwing Instrument Co., Philadelphia, Pa.:—Thwing Pyrometers, high-resistance multiple-recording pyrometers, also duriron and carborundum protecting tubes for thermocouples. A feature of their exhibit was a new apparatus for directly reading the moisture content of coal. The exhibit was in charge of Dr. Charles B. Thwing.

Toch Brothers, New York City, exhibited the different pigments used in making R. I. W. paints; also finished surfaces and hollow tile showing their water-proof paints and photos showing the many large buildings on which their paints are used. Among these are many of the largest structures in New York City. Messrs. E. A. Marx and F. A. Milligan were in charge.

Tolhurst Machine Works, Troy, N. Y., had on exhibit a large centrifugal driven from above and also two small laboratory centrifugals. Messrs. Tolhurst and Patton were in charge.

Troegerlith Tile Co., New York City:—Samples of their tile flooring in all different colors, their cork composition flooring, "Pollo Oil" and N. B. water proofing for floors. Messrs. Hyde, Richardson and Cheney were in charge.

Union Sulphur Company:—Refined sulphur and a most interesting sample of synthetic indigo made within the last two weeks by a Michigan manufacturer who wishes to withhold his name. Mr. Wilkinson was in charge.

United Gas Improvement Company, Philadelphia, Pa., exhibited by-products of coal-tar distillation, including inter-

mediates, light refined products, road compounds and pitches.

United Lead Company, New York City:—Lined and covered pipe, in lead, tin, brass and copper. Lead rope for caulking. Ulcoloy, a new alloy of 50 per cent Cu. and 50 per cent Pb. They also had on exhibit a piece of lead pipe 2000 years old from Rome. This was well preserved and attracted considerable attention. Messrs. L. B. Gallison, Thomas Wettstein, E. J. Bredehoft and O. M. Hoveman were in charge.

U. S. Government Departmental and Bureau Exhibits, Washington, D. C.:—This was the largest exhibit and contained a great volume of interesting apparatus, photographs, materials and publications. The feature which attracted the most attention was the demonstration of the Rittman oil cracking process, for making gasoline, benzol and toluol from petroleum. The Bureau of Foreign and Domestic Commerce showed all their publications, the Bureau of Mines showed the Westphalia and Draeger apparatus for mine rescue work; also Edison's electric mine lamp, first-aid cabinets and oxygen reviving apparatus. The lungmotor adopted by the U. S. army and navy was shown. The Geological Survey showed some of the economic minerals studied by them, and their various publications. Among the minerals were alunite, niter from Oregon and crude K₂SO₄-40-50 per cent obtained from the water of Owen's Lake, Cal. The agricultural and forestry service were represented by publications and photos. The Bureau of Soils and Plant Industry showed different fertilizers, kelps and brine from Searles Lake, Cal. The Bureau of Census was represented by their publications on chemical industries. The Bureau of Standards had a very large exhibit showing all their publications and the apparatus used in their work. This included gas calorimeters and meters, pyrometers, thermometers, hydrometers, standard weights, chemical apparatus and much other material. The following men were in charge: Bureau of Mines, Mr. M. F. Leopold; Rittman Process, Mr. S. H. Hartig; Foreign and Domestic Commerce, Dr. Thomas H. Morton, W. A. Johnston, Jr., Messrs. Brock and Penfield; Bureau of Standards, Dr. William Blum, E. C. McKelvy.

U. S. Smelting, Refining & Mining Co., Boston, Mass.:—Specimens of products from all of their subsidiary companies including different brands of copper, lead, spelter, selenium, gold, silver, platinum, palladium, crushed slag, hydrofluoric acid and miscellaneous ores. Also an exhibit showing the different stages in the process from ore to refined copper. Messrs. Sidney Rolle, A. Butts and W. C. Smith were in charge of this very well arranged and representative exhibit.

Valley Iron Works, Appleton, Wis., had on exhibit a complete Vesuvius sulphur burner, so arranged that all parts could easily be seen. Messrs. E. A. Peterson and R. W. Fannon were in charge.

Wilson-Maule Company, New York, who are shortly to move to their new factory at Whales Avenue and 142nd Street, Bronx, New York, had their "tapalog" on exhibition. This is a multiple-recording pyrometer giving on one chart four records and four colors of the temperatures of four different sources of heat. Mr. Wilson was in charge.

Zarembo Company, Buffalo, N. Y., showed interesting photographs of their evaporating apparatus of different sizes and designs.

Official Opening of the Exposition

The exposition was officially opened in the lecture hall on Monday evening. Dr. C. A. DOREMUS introduced the speaker of the evening, Dr. CHARLES H. HERTY, president of the American Chemical Society.

Dr. Herty, in his own delightful way, said there could be no more pleasing privilege than to open the First National Exposition of Chemical Industries ever held in this country and to extend congratulations to its originators, and he expressed the hope that the exposition might help the American public to find the right attitude toward the American chemist.

The German chemist has been largely responsible for the industrial successes of modern industrial Germany. Now since the war has cut off the importation of many chemical and allied products from Germany to this country, the American newspapers and the American public have found fault with the American chemist. But the American public should remember that as a nation it has never taken the same friendly attitude



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toward the American chemist which the German nation has taken toward the German chemist. This is a fact.

What is needed for the further development and growth of the chemical industry in America? The chemical manufacturer needs a little time to adjust himself to changed conditions. Brains and punch the American chemist has. But American ingenuity and energy cannot do without American capital, and American capital hesitates to make investments if they are to be rendered insecure by a sudden stoppage of the war. What is needed is protection—not forever, but just for a reasonable time until the American chemical industry has adjusted itself to new conditions. Dr. Herty's plea for a protective tariff for a limited time was very strong.

Dr. Herty also emphasized that now when the interest of the nation has been aroused in the chemical industry the public should be seriously warned against stock-jobbing concerns which are playing on the aroused interest in chemistry. It is the legitimate chemical industry which must be protected in its present healthy growth.

American Electrochemical Society Meeting

On Tuesday night a meeting was held at the Lecture Hall of the exposition by the New York section of the American Electrochemical Society.

Dr. COLIN G. FINK, of the Edison Lamp Works of Harrison, N. J., chairman of the section, opened the meeting by defining electrochemistry as the science which treats of the production of electricity by chemical changes, of the production of chemical changes through the agency of electricity, and of the electrical properties of chemical substances.

Electrochemistry became a real science in 1887 when the master mind of Wilhelm Ostwald systematized and interpreted the empirical results and generalizations of Berthelot of France, of Guldberg and Waage of Norway, of Willard Gibbs of America, of van't Hoff of Holland, of Arrhenius of Sweden, of Faraday of England, and of Bunsen of Germany. Electrochemistry has a decidedly cosmopolitan pedigree.

From an economic and commercial standpoint our own country ranks as the most important electrochemical center of the world.

Dr. Fink then introduced as the first speaker Mr. DAN. T. PIERCE of the Barber Asphalt Company, with "his lively troupe of trained molecules."

Mr. Pierce spoke on the properties and methods of mining and utilizing of Trinidad asphalt, showing a set of most interesting moving pictures. But the most interesting and highly novel part of his lecture was what he said about colloidal clay in Trinidad asphalt. For the first time the Brownian movements of colloids were shown in a moving picture on this evening.

There is a very important difference between Trinidad asphalt and any other bitumen in commercial use or of which we have any knowledge. This difference lies in the fact that Trinidad asphalt in its natural state contains a considerable proportion of mineral matter in colloidal form. That is to say, mineral particles so finely divided that they cannot be settled out or filtered out, and which are in constant motion.

For a great many years it has been observed that there was a small residue of mineral matter recovered from the most carefully filtered solutions of Trinidad asphalt. This residue was never identified or satisfactorily accounted for until Mr. Clifford Richardson, the engineering chemist of The Barber Asphalt Paving Company, conceived the idea that this matter consisted largely of colloidal clay. This conception on Mr. Richardson's part followed closely upon a lecture on colloids by Professor Ostwald at the laboratory of the College of the City of New York, in March, 1914.

Subsequent investigations with the aid of the ultra-microscope and the laboratory work carried out by Mr. Richardson and his assistant Dr. Schneeberger, have verified the belief that in Trinidad asphalt we have a true bitusol—

that is to say, dispersed solid colloids in solution in bitumen. The extreme fineness of this colloidal matter is demonstrated by the fact that it is not deposited from solutions of the bitumen after standing for years, and that under the ultra-microscope it is demonstrated to be in that active state of motion called the Brownian movement which is characteristic of all highly dispersed colloidal material.

The moving pictures [shown by Mr. Pierce] are unique in that they afford the first opportunity to observe the Brownian movement of colloidal matter in form of moving pictures. These pictures were taken by joining the lens of a cinematograph camera to the eye-piece of the ultra-microscope, thus reproducing on the film the movement observed by the eye through the microscope. So far as is known this is the first time such a motion picture has been made and this is the first exhibition of the film.

When it is considered that the colloidal particles are as small or smaller than one ten-thousandth of a millimeter, this example of motion photography becomes all the more remarkable.

A few words will emphasize the importance of Mr. Richardson's discovery with relation to the asphalt paving industry. The theory of an asphalt pavement is that of a mixture of sands in which by grading the voids will be reduced to the lowest possible limit, bonded together with the asphalt. A mixture contains from, say, 12 to 18 per cent of filler dust which will pass a screen of 200 meshes to the inch. The larger the proportion of fine sand in a mixture the more bitumen it will carry and the more durable will the pavement be, for the obvious reason that the more finely the mineral matter is divided, the larger surface area it presents for the adhesion of the asphalt.

The presence of colloidal matter carries us a step further, for not only does colloidal matter add to the paving mixture particles of a fineness never artificially combined with bitumen—it also gives us the advantage of the absorptive power of colloids. That is to say, the power such matter has of holding the asphalt cement about itself in the form of a film.

The filler ordinarily used in an asphalt mixture is estimated to run about 192,000,000,000 particles to the pound, and none of it is of colloidal fineness. The dimensions of such filler would be from 8/100 to 25/10,000 of a millimeter. Imagine a cube having a dimension of 1 centimeter reduced to particles of the coarsest colloidal size—1/10,000 of a millimeter—and we have increased the surface area of the material in the 1 centimeter cube 100,000 times.

The importance of colloidal matter in an asphalt mixture is therefore due to two causes, namely, the vast increase in the surface area presented, and the tenacity and thickness of the film of asphalt which surrounds the colloidal particles.

For many years the industry has been familiar with what it called the "stability" of Trinidad asphalt. Colloidal chemistry has now enabled us to account for this characteristic on rational grounds.

Mr. LINN BRADLEY, of the Research Corporation, followed with an interesting address on "the solution of the smoke, dust and fume nuisance by electrical precipitation" by the Cottrell process. This address gave a very good concise summary of the present status of the process, and is reserved for publication in a future issue.

The last speaker of the evening was Mr. HARRINGTON EMERSON, who spoke on "efficiency in the conservation of our natural resources." His theme was: "Utilizing Efficiently Our Natural Resources."

The natural resources of the universe become *our* natural resources when we can use them for our service. They are only partly our resources when we merely adjust ourselves to them as parasites. They are distinctly ours when we can control and harness them. About sixteen years ago, I visited Snoqualmie Falls, near Seattle. A great river plunged over a ledge and fell to the gorge below, a height 100 ft. greater than that at Niagara. Here was a tremendous natural resource, not yet harnessed, not yet ours.

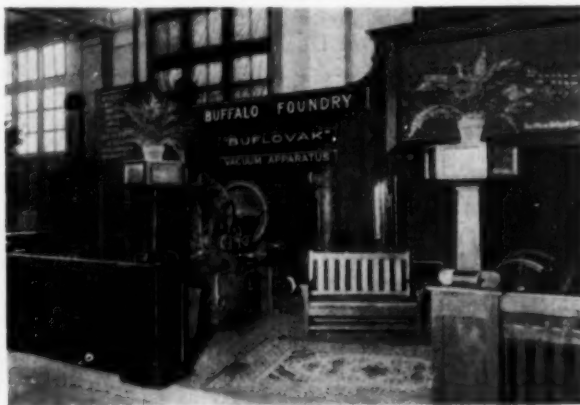
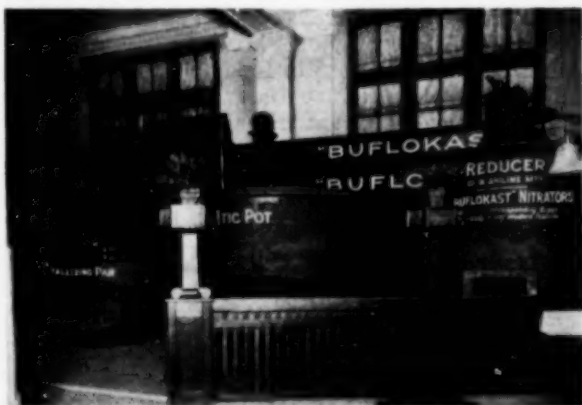
I visited the same falls this summer. Scarcely a brook trickled over the bared ledge, but miles away in Seattle and in Tacoma, trolley cars were running, machinery was driven, lights were blazing, because the falls had been harnessed and controlled. The natural resource was *ours*, and it was being efficiently utilized in forms that were no longer natural, but distinctly a product of man's mind.

To utilize efficiently our natural resources we must know what resources are natural, what is their extent,



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what control we can attain over them, what part of those controlled has value, what the maximum value is, our efficiency in extracting the values.

Natural resources are physical, mental and emotional. The sun is one of our greatest natural resources.

The evaporation of water is one of the most universal phenomena in nature, but it took millions of years before an animal wise enough to boil water appeared on earth, and it took several hundred thousand years more before man was wise enough to confine steam in a strong container and make it push a piston. . . .

The radiations from the sun are incomparably our greatest natural resource, but as yet the efficiency of utilization is very low. There is probably no field so promising of immediate great returns as more efficient utilization of that small fragment of the sun's radiation which the earth intercepts. At the present time only about one-thousandth part is utilized at all. It is conceivable to me that we may ultimately discover some device by which condensation of the moisture of the air into rain can be concentrated at one point, even as we now divert the water of a stream into a flume, lead it many miles away and there harness it. More immediate and practical is our power to make the sun serve us by planting and covering the available surface of the earth with more suitable vegetation.

Mr. Emerson then discussed our natural mental and emotional resources.

The human seed is so small that it requires a microscope to be seen. Give this seed nourishment, heat, sunlight, and air, and it grows, perhaps into one of the great leaders of humanity. Socrates was the teacher of Plato, Plato was the teacher of Aristotle, Aristotle was the tutor of Alexander, and at 33 Alexander was weeping because there were no more worlds to conquer. What kind of a world would it be if the human plasm developed exclusively into such sequences as I have enumerated?

On the one side we would have the infinite material uni-

verse extending from the center of the earth to the uttermost confines of space, and on the other infinite mental and moral capacities of human excellence utilized efficiently to conquer these infinite resources for the benefit of humanity. These are the two biggest problems in the world as I see them and every act, every thought, every emotion can be gaged with reference to their solution. By far the more important of the two is the efficient use of the human elements.

Mr. Emerson then gave instances how some nations do better with their natural resources than others, so that we can at least set up comparative standards. "Henry Ford is able to make American mechanics worth to themselves \$5 a day instead of \$3. He makes the worth of his company \$10 a day instead of \$4. If all American workers were doing as well as the Henry Ford workers they would be earning \$40,000,000 a day more for themselves and would be producing \$80,000,000 more a day than the workers now do."

Meeting of the American Institute of Chemical Engineers

On the evening of Wednesday, Sept. 22, a meeting of the American Institute of Chemical Engineers was held. The president, Dr. GEORGE D. ROSENGARTEN, made a few opening remarks and then introduced Dr. THOMAS H. NORTON, of the Department of Commerce, Washington, D. C., who spoke on "Foreign Markets for American Chemicals." The first part of the lecture was augmented by numerous lantern slides, showing the loading, unloading and transportation of American goods in foreign countries. This part of the talk was very general and included such apparatus as agricultural implements, oil engines, cement, etc. He emphasized

the importance of packing goods for export very securely, and showed pictures of damaged goods which had arrived in foreign port. Every facility of the Department of Foreign and Domestic Commerce is open to manufacturers to assist them in their export problems.

Detailed statistics were then given showing the increase in our exports of chemicals during the last year, the figures for the month of June, 1915, showing a 161 per cent increase over the month of June, 1914. Data are now being obtained on the geographical distribution of the export increases. The chemical market of the world was placed at \$598,000,000 in value, the share of the United States being but \$48,000,000.

The potash situation was then briefly discussed, and the active part which the Department of Commerce has taken in this work was explained. Many processes have been proposed, but few are commercially available. The efforts to solve the potash problem are sure to avail something before very long, but the commercial process and the capital must be brought together.

The dyestuff situation was next briefly discussed as of equal importance to potash. The Department of Commerce has also taken an active interest in working out this problem and has endeavored to bring the capitalists in touch with the engineer and chemist. Dr. Norton thought it might be a year or two before our production of dyes would equal our demand, but if sufficient protection is assured we are bound to have our independent industry.

Mr. I. F. STONE, president of the National Aniline and Chemical Company, then presented a lecture on the aniline dye situation. This lecture is given in full elsewhere in this issue.

Meetings of the American Paper and Pulp Association

On the morning and afternoon of Thursday, Sept. 23, the newly formed technical section of the American Paper and Pulp Association held two well attended and very interesting sessions. The morning session was opened by the presidential address of Mr. FRANK L. MOORE. Other papers on the program for the two sessions were:

"Some Experiences in Refining Groundwood Slivers," by D. L. BELLINGER.

"A Method of Determining the Current Capacity of a Cell in an Electrolytic Bleach Plant," by F. B. WHEELER.

"The Relation of Ink and Paper in Halftone Printing," by H. P. CARRUTH.

"The Possibilities of Accurate Determination of Groundwood in Papers," by MAX CLINE.

"Work of the German Association of Cellulose and Paper Chemists," by HENRY F. OBERMANN.

"Suggestions for the Adoption of Standard Tests and Processes," by OTTO KRESS.

"The Elimination of Fuzz in Soda Pulp by Proper Cooking Conditions," by S. D. WELLS.

"Prospects of Relieving the Scarcity of Dyestuffs Used in the Paper Industry," by I. F. STONE.

Meeting of the American Chemical Society

The meeting of the New York Section of the American Chemical Society on the evening of Friday, Sept. 24, was opened by the address of the chairman, Dr. T. B. WAGNER.

Dr. LEO H. BAEKELAND followed with an admirable address on "Industrial Chemistry." This is published in full on page 677 of this issue.

Mr. HOWARD H. GROSS, president of the Tariff Com-

mission League, spoke on "The Tariff Question" (See page 676 of this issue).

The concluding address of the evening was made by Dr. SAM. P. SADTLER, of Philadelphia, Pa., on "Some American Contributions to Industrial Chemistry." The chief part of this lecture dealt with the development of the American petroleum industry, but the author also dealt with the fertilizer industry, the water gas process, the industries of sulphur, cottonseed oil, starch production, and the electrochemical and electrometallurgical industries. An account of this interesting lecture is reserved for one of our next issues.

Other Lectures Held at the Exposition

The afternoons were devoted partly to the demonstrations of moving pictures and partly to special invited lectures. The program of the latter included the following:

"Accident Prevention in the Chemical Industries," by FRED W. KEOUGH.

"Transportation and Shipping Facilities with Foreign Countries," by WELDING RING.

"The Manufacture of Chocolate," by D. C. LIGHTNER.

"Explosives," by J. L. TAYLOR.

"Potash," by H. A. HUSTON.

"Paint," by G. B. HECKEL.

"Chemical Effect of Dynamiting the Soil," by GEO. FRANK LORD.

"The History of Cement," by E. S. CONWELL.

"The X-ray," by W. D. COOLIDGE.

"Refined Tars for Road Construction and Maintenance," by PHILIP SHARPLES.

"Synthetic Phenol and Picric Acid," by A. H. NEY (published in full on page 686).

"Research and Progress in American Manufacturing," by RAYMOND F. BACON.

"Manufacture of Vegetable Oils," by CHARLES V. BACON.

"Alundum and Crystolon," by M. A. WILLIAMSON.

"Heat Insulation with Kieselguhr," by D. S. COLLINS.

"The Evolution of the Glass Industry," by ROBERT L. FRINK.

"The Possibilities of Niagara for American Electrochemistry," by THOMAS H. NORTON.

"The Great Pan-American Opportunity," by JOHN BARRETT.

"Opportunity for American Chemical Industry," by E. E. PRATT.

The three last-named lectures were presented in the concluding session, held on Saturday night under the auspices of the New York Section of the American Electrochemical Society, with Dr. Colin G. Fink in the chair. We reserve a number of these lectures for publication in future issues.

Recent Chemical and Metallurgical Patents

Oils

Catalyser for Hydrogenation of Fatty Oils.—A catalyser of electrolytic nickel for the hardening of fatty oils is patented by CARLETON ELLIS of Montclair, N. J. The method of preparing this nickel is to deposit it from the sulphate or ammonium sulphate solution using a nickel anode, and as cathode a mass of powdered charcoal, graphite or a metal support, capable of occluding hydrogen. The nickel may deposit in the form of a spongy mass on the charcoal particles, powdered graphite or metal support. A current of relatively high density is employed for this purpose. Five per cent of a titanium salt may be added or a small amount of zinc sulphate. The titanium aids in hydrogen absorption

and the zinc sulphate favors the production of a spongy nickel.

The prepared catalyser is introduced into fatty oil heated to 180 deg. C. Hydrogen or a hydrogen-containing gas is introduced and the oil hardened to the desired point. The catalyser may be placed in a tower through which the oil is caused to flow, or it may be agitated with the oils in the presence of hydrogen. The catalyser may be regenerated when it becomes spent by oxidizing and again reducing.

The advantage claimed for this catalyser is that it provides a pure material which may be used for a considerable length of time without becoming poisoned. In wet methods, such as precipitating nickel by alkali from the sulphate solution, it is difficult to free the precipitates from sulphates, and sulphides may form when the precipitate is reduced with hydrogen at 350 deg. and catalyser will be poisoned. The reduction by hydrogen also has a tendency to sinter the product, thereby causing a loss in catalytic value. The use of nickel without a carrier of clayey material removes an objection to the catalytic process, viz., the disagreeable earthy taste imparted to the oil by the clayey material which is difficult to remove. (1,151,003, Aug. 24, 1915.)

Iron and Steel

Process of Treating Cast Iron.—For certain purposes it is desirable that all of the oxygen should be removed from cast iron in order that the iron may be free from chilling properties and the carbon in the flaky graphite rather than the combined form. A process for accomplishing this purpose is patented by JOSEPH E. JOHNSON, Jr., of New York City. In this process the cast iron is heated in an electric furnace, preferably of the inductive type, to about 3000 deg. Fahr. This causes the occluded oxygen to combine with silicon and iron present, silica rising to the top of the bath, and CO escaping as bubbles. In order not to have an oxidizing atmosphere above the bath, CO gas is injected into the chamber above the charge, even up to 100 per cent if necessary. Hydrogen or any satisfactory gas could also be used, or a vacuum may be maintained above the charge. The process is preferably carried out in an induction furnace, as the high conductivity of the bath would require very large electrodes were an electrode furnace used. (1,150,201, Aug. 17, 1915.)

Alloys

Copper-Titanium Magnesium Alloys.—In the elimination of gases and deleterious substances from copper and copper alloys for casting purposes cupro-titanium has been used. In order to still retain the effects of the titanium and further improve the metal it is proposed, in a patent of CHARLES VICKERS of Niagara Falls (assigned to the Titanium Alloy Manufacturing Company) to add an alloy of copper, titanium and magnesium to the bath of molten metal. It is believed that the titanium combines with the oxygen and other undesirable elements forming titanate acid and the compounds of magnesium combine with them to form slags so fusible that they are entirely eliminated from the bath. The surface of the resulting castings are substantially free from undesired specks and blemishes. Ordinarily the constitution of the alloy to be added would be about 5 per cent titanium, 93 per cent copper, and 2 per cent magnesium. Usually about ten minutes is required for the elimination of impurities. (1,151,744, Aug. 31, 1915.)

Alloys of Iron, Cobalt, and Chromium.—Ternary alloys of iron, cobalt, and chromium are described in a patent issued to ELWOOD HAYNES of Kokomo, Ind. In a previous patent (No. 873,945) he described alloys of

cobalt and chromium which had many valuable properties. As a rule the hardness increased with the amount of chromium present. These alloys were somewhat difficult to work, and were costly on account of the high temperature required. Their hardness is also greater than is required for making knives, auger bits, gimlets, etc., and filing and grinding are somewhat difficult. The addition of iron softens these alloys to any desired degree, but they will be of sufficient hardness for saws and similar tools, being as hard or harder than the ordinary tempered steel. A series of these alloys with low carbon content was prepared with a constant percentage of chromium (20 per cent) and percentages of iron from 10 to 75 per cent. They show little variation in physical or chemical properties so long as they contain 5 per cent or more of cobalt and from 20 to 25 per cent of chromium. They are malleable at a bright red heat and retain a beautiful luster. Several bars of these alloys were ground smooth and covered with a strong solution of ammonium chloride. These were then subjected to moist air for several days, but failed to show any stain or tarnish. It is desirable to have a low percentage of carbon (1 per cent or under) in these alloys. Ferrochromium may be used in making the alloys, but on account of its usual high carbon content, it is necessary to first remove the carbon. At least 10 per cent of chromium should be in these alloys to insure the desired properties, the preferable amount being 20 to 30 per cent. (1,150,113, Aug. 17, 1915.)

Notes

Overhead Trolley and I-Beam Carrying Equipment is described in the recent catalog of the Richards-Wilcox Manufacturing Co. of Aurora, Ill. Their apparatus are made for carrying capacities up to 4 tons, and are useful where floor space is limited.

Teniente Topics, a monthly booklet devoted to the interests of the Braden Copper Co. has been launched forth on its first issue in June. It is published at Sewell, Chile, by the Teniente Publishing Co., the company consisting of men connected with the Braden Copper Co. The object of the publication is to give descriptions of the daily activities at Braden for outsiders and to give also those at Braden descriptions of activities in other fields.

Reducing Sulphur Content at Robesonia Furnace.—After an exhaustive study, accompanied by numerous practical tests, of the possibility of reducing the sulphur content of its ore burden, the Robesonia Iron Co., at Robesonia, Pa., which specializes in low-sulphur, low-phosphorus pig iron, has adopted the recommendations embodied in a report by Mr. John W. Gocher, consulting engineer, of Johnstown, Pa., and is now constructing a plant, under his supervision, to carry out the plan proposed. At the present time the ore, which is from the well-known Cornwall mines, is roasted in Giers kilns, the lumps as they come from the mine being roughly broken by hand before charging. It is proposed to crush and screen the ore, all that passes through a $\frac{3}{8}$ -in. screen to be sintered in Greenawalt sintering pans, while for the present all of the coarse ore, ranging in size from $\frac{3}{8}$ in. to $2\frac{1}{2}$ in., will be roasted in the Giers kilns, as heretofore. It is expected that the sulphur content of the fine ore will be reduced from about 2.4 per cent as it comes from the mines to not over 0.2 per cent in the sinter. The coarse ore roasted in the kilns will average about 0.6 per cent sulphur. After a suitable trial period, with various proportions of sinter and roasted ore, if the results are as expected the amount of sinter will be gradually increased, with the idea of ultimately sintering all of the ore.

Rennerfelt Electric Furnace

The first Rennerfelt furnace was constructed in 1912 at Hallstahammars Iron Works in Sweden. In several important details the new furnace was quite different from previous types. Mr. Rennerfelt, under whose supervision the work was carried on, obtained such satisfactory results that within one year a steel foundry containing four Rennerfelt furnaces was established.

Since then the increased use of the furnace has been very rapid. By 1914, fifteen furnaces, ranging in size from 600 lb. to 3 tons, had been placed in operation or ordered, and by July 1 of this year this number had increased to thirty, of which four are found in England, five in Russia, two in Switzerland and the rest in Sweden and Norway. It is very well adapted for the manufacture of tool steel and steel alloys, for steel castings, for the melting of copper, brass, and for any other purpose for which a high heat and a quiet metal are required.

DESCRIPTION OF THE FURNACE

The Rennerfelt furnace has generally been built with a horizontal, cylindrical steel shell, supported on rollers or trunnions, and with one close-fitting charging and casting door on the side or in the end of the furnace. The shell is lined with asbestos board, next to which

This form of arc is one of the special features of the Rennerfelt furnace. The heat generated in the arcs is concentrated in the bath, though the electrodes do not actually touch or even approach the slag or metal. The arcs are sweeping all over the central place underneath the points of the electrodes, insuring a uniform heating of the charge and rendering the slag very fluid and chemically active.

When the furnace is to be preheated the current is simply turned on, there being no necessity for solid fuel or metal in the furnace. This can be charged with cold or liquid metal. During the charging the electrodes may be drawn back and raised so as to prevent their being injured. Once the furnace is charged, the electrodes are adjusted into proper position, the door is carefully closed, and the current turned on.

For smaller furnaces the electrodes are manually adjusted. For larger furnaces automatic regulation is used. Only the horizontal electrodes need adjusting during the operation.

The consumption of electrodes is very low. In a 1200-lb. furnace running continually on charges of cold scrap and pig, the average consumption of electrodes has been found to be 5 to 6 lb. per ton of steel. Even when melting pig iron and afterward decarburizing it

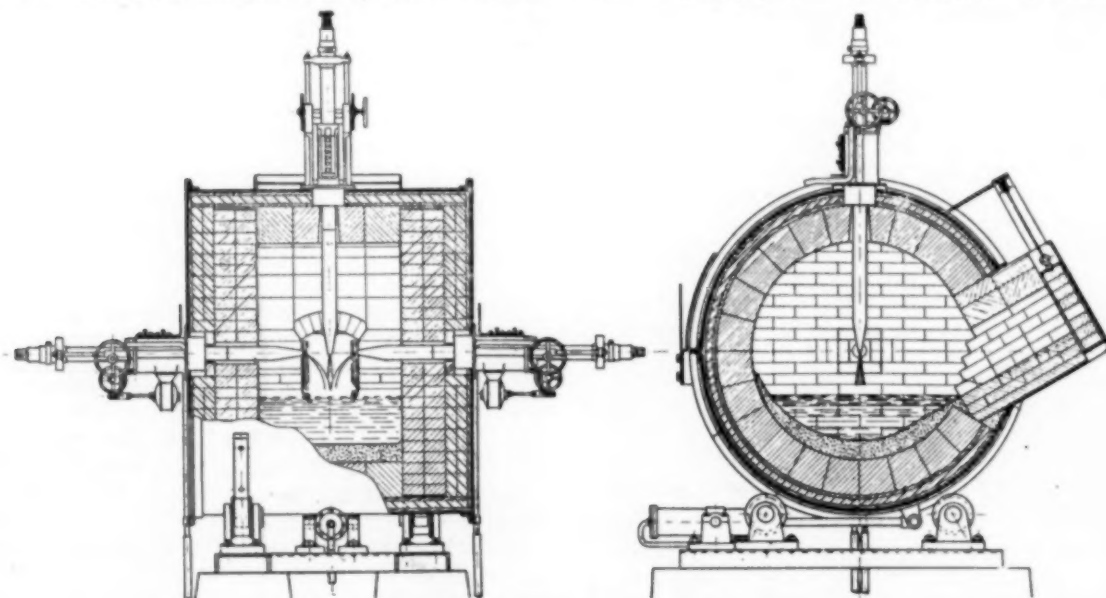


FIG. 1—RENNERFELT ELECTRIC FURNACE

firebricks are built in rings. Inside this is the actual acid or basic lining.

Centrally in the roof and horizontally through the gables of the sides enter water-cooled bronze electrode-holders, through which slide three Acheson graphite electrodes turned to exact size. The diameter of these electrodes varies from $1\frac{1}{2}$ in. for the small sizes up to 4 or 5 in. for the larger sizes. As stated, any available current can be used. In case of a direct current, the horizontal electrodes are coupled in parallel, while the vertical electrode is connected with the other pole.

If three-phase alternating current is used, it is converted in stationary transformers by the Scott arrangement into two-phase current at 70 to 110 volts. One phase of the current is connected to each side electrode. The central vertical electrode is connected to the common point between the two phases of the transformer. The currents entering through the horizontal electrodes neutralize one another, but the action of the returning current into the central electrode generates a magnetic field which deflects the arcs downward to the bath, forming an inverted arrow-head.

by means of ore, the consumption of electrodes has not exceeded 6.6 lb. per ton in spite of the highly oxidized slag carried in the charge.

Some curves are reproduced in Fig. 2 which illustrate the performance of the Rennerfelt furnace when melting cold scrap. The curves are obtained from a 600-kg. furnace running on tool steel in a Swedish mill at Trollhättan. The furnace is rated normally at 125 kw., but as indicated by the curves only about 100 kw. are utilized. It is running day and night on cold charges, drawing its power from the adjacent large government power plant.

Certain portions of the curves are also affected by the operation of some rolling mills, which caused very strong fluctuations in the power curve in spite of heavy flywheels provided to reduce fluctuation. The curve is rather peaky when the rolling mills are on, but comes down almost to a straight line at night and noon, when the furnace alone is working. The peaks of the furnace are comparatively low and rarely exceed 50 per cent of the normal load.

The $1\frac{1}{4}$ -ton furnace is rated at 200 kw., and is being

operated without any automatic regulators or similar protective apparatus, receiving the surplus energy from a hydroelectric power plant of about 800-hp. capacity. Only an ordinary oil switch with time relays is needed to insure sufficient protection from the generators, the circuit breaker being adjusted so as to operate at 400 kw., or double normal furnace load. The furnace works as a large inclosed arc lamp, practically without any disturbing influence from the charge beneath the arcs.

Simultaneous readings of kilowatts, volts and amperes indicate a very satisfactory power factor. In one instance a value of 0.97 has been obtained at a furnace operated with a current of 50 cycles.

A very interesting paper on the use of liquid ferromanganese in the steel processes was presented by Axel Sahlin at the fall meeting, 1914, of the (British) Iron and Steel Institute. He speaks about the use of the Rennerfelt furnace in this connection and gives details of a number of tests made to ascertain the efficiency of the furnace. At one test, for instance, 1 ton of ferromanganese was melted in 2 hr. 45 min. The current consumption per ton amounted to 441 kw.-hr. at a temperature of 1500 deg. in the furnace when the metal

limit of 127,000 lb. per square inch and a tensile strength of 177,800 lb.

Soft steel with carbon around 0.20 is made daily in several of the Swedish plants. It is converted into steel castings of most intricate and thin-walled forms. Such steel has at testing shown a tensile strength of 60,000

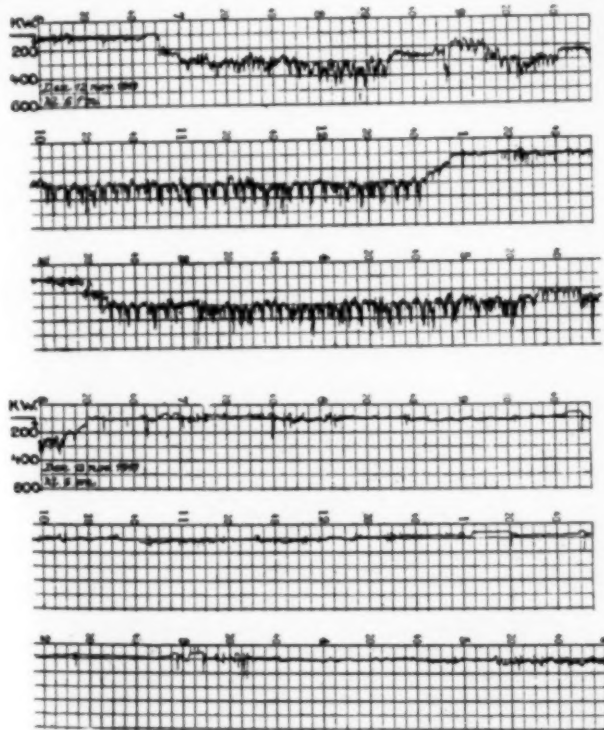


FIG. 2—FURNACE-PERFORMANCE CURVES

was charged. The corresponding efficiency of the furnace is 78 to 79 per cent. Loss of manganese was about 1 per cent.

	C. %	Mn. %	Fe. %
Analysis before melting.....	6.07	78.90	11.70
Analysis after melting.....	5.69	79.50	12.30

The steel produced by the Rennerfelt furnace is of excellent grade. From pig iron and ore, tool steel has been produced of equal quality with the best crucible steel.

A recent test of a piece of high-carbon steel produced in this electric furnace showed an elastic limit of 68,270 lb. per square inch and a tensile strength of 103,800 lb. per square inch with an elongation of 12.3 per cent. The steel analyzed C., 1.44 per cent; Si., 0.30 per cent; Mn., 0.36 per cent; S., 0.021 per cent, and P., 0.017 per cent.

Another piece with 0.96 per cent showed an elastic

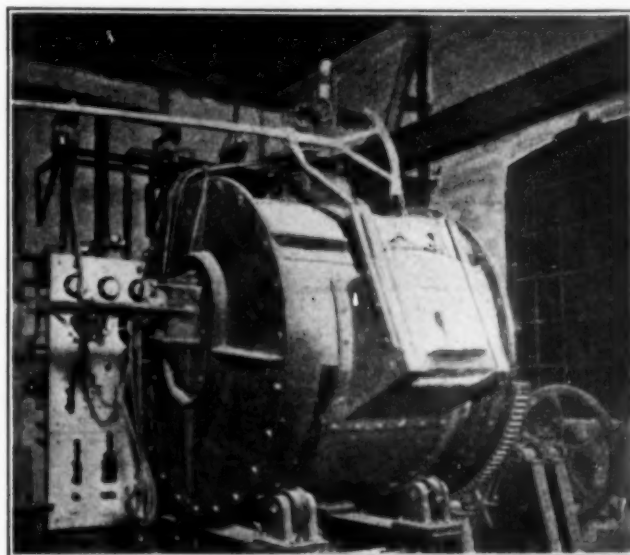


FIG. 3—1 1/4-TON FURNACE, HALLSTAHAMMAR WORKS

to 75,000 lb. per square inch, with an elongation of 20 per cent and more.

The Rennerfelt furnace is being introduced in this country by Messrs. Hamilton & Hansell, 17 Battery Place, New York City.

Protecting Polyphase Motors Against Phase Failure and Reversal

Accidental rotation of a motor in a direction opposite to that which the operator expects is often liable to result disastrously. An elevator may be dashed to the pit

or through the overhead—costly machines, cranes, hoists, etc., may be seriously damaged if the direction of rotation is unexpectedly reversed when the starting device is closed. With alternating-current polyphase motors this may happen due to reversing of the phases and engineers have turned their attention to the problem of eliminating this source of accident. Failure of one phase may also cause burning out of the motor.

A new compact type of phase failure relay, shown in the accompanying illustration, has been developed in the engineering department of The Cutler-Hammer Manufacturing Company, Milwaukee. This device is suitable for use on any system similar to a



PHASE-FAILURE AND PHASE-REVERSAL PROTECTIVE DEVICE

vertical motor having a two or three-phase stator winding and a squirrel cage rotor winding. The rotor shaft extends at the top, and to this extension a casting is secured carrying contacts designed to close a pilot cir-

cuit which controls the motor starter. This phase failure relay provides against abnormal drop in voltage, against failure of one of the phases and against reversal of the phases.

If the supply voltage falls below about 70 per cent of normal the relay opens the control circuit of the motor controller and keeps it open until the line voltage returns to at least 85 per cent of normal. These limitations

can be adjusted before shipment to suit special conditions.

In case of phase failure, caused by the opening of one of the supply lines at any point, the relay opens the control circuit if the motor is under appreciable load and keeps it open until the fault is corrected. If the load on the motor is very light, so that no harm would result from its running single phase on account of the phase failure, the device may not operate until the load is increased or the motor shut down. If the motor is at rest at the time of phase failure the relay will act immediately. Thus the motor is allowed to run as long as no damage can result.

In case of phase reversal the relay opens the control circuit immediately and keeps it open until the phases are reconnected in the proper order. Accidents due to the motor running in the wrong direction when started up are avoided.

Water Distilling Apparatus

The necessity for distilled water of a high degree of purity in laboratories and manufacturing operations has led to the development of more efficient apparatus. The latest Barnstead-type water-stills furnished by Messrs. Eimer and Amend of New York City are for



BARNSTEAD WATER STILL, TYPE L

heating by steam, gas or electricity and the general type is shown in the accompanying illustration.

The operation of these stills is automatic and continuous. The water produced is free from ammonia, and all gaseous and organic impurities. The construction is such that the heat generated is used to preheat the incoming raw water.

The gas and electric types are portable and can be placed on the laboratory bench, or supported on a bracket attached to the wall.

The boiler of the still is easily accessible for thorough

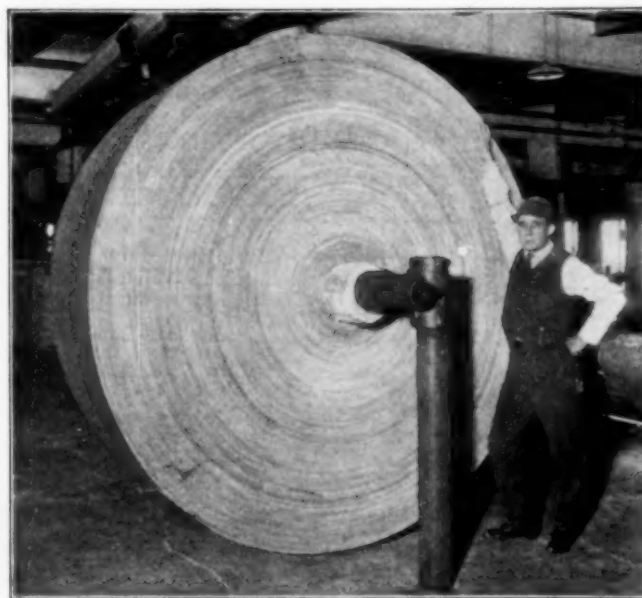
cleaning by simply turning the thumb clamps which rigidly hold the condenser and hood to the boiler.

The electrically heated still is furnished with replaceable heating units which can be attended to by the operator.

Gigantic Conveyor Belts

Conveyor belts of great size have been tried and found successful by the California-Hawaii Sugar Refining Company. In February, 1906, they installed a 36-in. 7-ply Goodrich belt for the purpose of catching 125-lb. bags from a fall of 4 ft. and conveying them. This belt received and carried 2,000,000,000 lb. of sugar before showing any radical signs of wear.

Recently the same company ordered another belt from the B. F. Goodrich Company to be 1443 ft. long and 36 in. wide. This belt weighed 11,983 lb., and is shown in the accompanying illustration.



GIANT CONVEYOR BELT

Figuring eight hours' run without any delays a bag of sugar would drop onto the belt every nine seconds, and if the speed of the belt was such that it made twenty-six or twenty-seven revolutions every eight hours the bags would rest 12 ft. apart and a continuous load of 7500 lb. would be carried.

Chilean nitrate exports to the United States are reported to be again normal. Direct exports to certain European countries have increased somewhat, while to others they are entirely suspended.

An electric furnace for operating above 2000 deg. C. will be described in a paper to be delivered before the October meeting of the American Chemical Society in Pittsburgh by Mr. Frederick T. Snyder, president of the Snyder Electric Furnace Co. of Chicago. The furnace is adapted to be operated on powdered material.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in March, 1915, was sixty-three. The total quantity of ore milled during that period was 2,421,218 tons. There were 9840 stamps in operation, with an average duty of 9.35 tons per 24 hours. Tube-mills in commission numbered 314. The yield for the month was 753,935 fine ounces gold. The report indicates a larger tonnage milled and more equipment in operation than a year ago. The yield also shows an increase.